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Aerobic Secondary Treatment of Potato Processing Wastes

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27 *Abstract*
The R. T. French Company, of Shelley, Idaho, has demonstrated the feasiblity of using a complete mix activated sludge unit for secondary treatment of potato processing wastes. During the 1969-1970 processing season, both the activated sludge process and a flow through aeration process without secondary clarification were studied. The activated sludge unit was demonstrated to be capable of BOD removals, in excess of 90% over extended periods, with coliform removals in excess of 96%. With the flow through system, BOD removals ranged between 70 and 80%. Analysis of data obtained revealed that both the quantity of excess sludge produced and the amount of oxygen required were functions of the BOD removal rate and the mixed liquor volatile suspended solids concentration. The substrate removal rate coefficient was shown to be temperature dependent. The prevailing low air temperatures at the Shelley location did not cause system failure, but data obtained demonstrated the need to consider temperature loss in system design. Total annual treatment costs, excluding costs for waste activated sludge disposal, were estimated to be $.038 per lb BOD applied, and $.021 per lb COD applied. Operation of thickener-clarifier on combinations of silt and biological solids was not successful. Failures with this unit demonstrated a need for the development of special silt removal and handling equipment for potato processing. (Lowry-Texas)

G(WRSIC abstract)

Abstractor Mark V. Lowry	*Institution* Texas Univ, Austin

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HAS DEMONSTRATED.

Aerobic Secondary Treatment of Potato Processing Wastes

by

The R. T. French Company
Shelley, Idaho

for the

ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE

Program 12060 EHV
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ABSTRACT

A new secondary treatment facility at the R. T. French Company, Shelley, Idaho, has demonstrated the feasibility of a complete mix activated sludge system for secondary treatment of potato processing wastes. The secondary treatment facility was designed for an average daily flow of 1.25 million gallons per day and a BOD loading of 14,100 pounds per day. Frequent aerator shutdowns following mechanical problems have limited oxygen transfer and biological activity in the aeration basins; however, BOD removals of over 90 percent have been obtained for extended periods of time, demonstrating the applicability of the activated sludge process for treating the wastes. These removals have been obtained with: (1) MLSS concentrations between 2,000 mg/l and 8,000 mg/l, (2) aeration basin D. O. concentrations between 0.3 mg/l and 5.2 mg/l, (3) aeration basin temperatures between 45 degrees F and 67 degrees F, (4) aeration basin pH between 7.1 and 8.4, (5) organic loadings between 10 and 120 lb BOD/1,000 cu ft/day, (6) hydraulic detention times of 0.9 to 8.7 days, and (7) BOD/MLVSS ratios of 0.15 to 0.47.

This report was submitted in fulfillment of Grant No. WPRD 15-01-68, Program 12060 EHV, between the Environmental Protection Agency and R. T. French Company.

Key Words: Potato processing wastes, food processing wastes, activated sludge, secondary treatment, treatment costs.

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SECTION I
SUMMARY

During the 1969-70 potato processing season, aerobic secondary treatment of potato processing wastewater at R. T. French Company was studied. These studies were partially supported by an Environmental Protection Agency demonstration grant.

On the basis of the results presented in this report, the following conclusions have been reached:

1. Treatment of potato processing wastewater by a fully aerobic aeration process, specifically by the activated sludge process, is feasible.
2. BOD removals of over 90 percent have been obtained for sustained periods of time while operating the plant as an activated sludge system.
3. BOD removals of between 70 and 80 percent have been obtained while operating as a flow-through aeration system, without secondary clarification.
4. Coliform removals in excess of 96 percent were obtained in the activated sludge system.
5. High pH values of influent process wastewater were buffered in the aeration basins and were not detrimental to treatment efficiencies.
6. Low air temperatures have not caused failure of the activated sludge process. Data obtained do, however, demonstrate the need to consider temperature loss in system design.
7. The quantity of excess biological sludge, ΔX_v, was found to be a function of the BOD removal rate, S_r, and the average MLVSS (mixed liquor volatile suspended solids), X_d.
8. The substrate removal rate coefficient, k, was found to be a function of temperature, as follows:

   $$k = 0.016 \times 1.17^{(T-20)}$$

9. System oxygen requirements are a function of the BOD removal rate, S_r, and the average MLVSS, X_d, in accordance with the following equation:

   $$O_2 = 0.48\ S_r + 0.03\ X_d$$

10. Total annual activated sludge treatment costs are estimated to be $0.038 per pound of BOD applied and $0.021 per pound of COD applied. These costs are for secondary treatment only and do not include waste activated sludge disposal.

11. The clarifier-thickener approached 100 percent suspended solids removal when operated as a straight silt removal system.

12. Operation of the clarifier-thickener for dewatering secondary sludge in combination with silt was not successful.

13. Operation of the clarifier-thickener, vacuum filter, and solids conveying system has demonstrated the need for special designs for handling silt removed from potatoes.

SECTION II
RECOMMENDATIONS

It is recommended that future studies be initiated to determine feasible methods to concentrate, dewater, and dispose of the large quantities of waste activated sludge from a potato processing waste treatment facility. These studies should be concentrated on methods which could produce an end product palatable for use as cattle feed.

Development of a system to mix and dewater silt and waste activated sludge effectively would be beneficial to use as a standby for a cattle feed disposal system. Chemical additions would probably be required to meet this objective.

Additional studies in the area of sludge bulking control are needed. Development of a feasible control system would enhance the value of the highly efficient activated sludge process in treating potato process wastewater and other similar industrial wastes.

SECTION III
INTRODUCTION

SCOPE

Aerobic secondary treatment systems were studied at the R. T. French Company in Shelley, Idaho, during the 1969-70 potato processing season to ascertain their efficiency in treatment of potato processing wastes. These studies were conducted as an Environmental Protection Agency demonstration grant project.

The objectives of the grant were to:

1. Demonstrate the feasibility of secondary treatment of potato processing wastewater by a fully aerobic aeration process; specifically by the activated sludge system.
2. Determine the BOD removal efficiency and effluent characteristics when the system is operated as:
    a. An activated sludge system with biological sludge being returned to the aeration basins to maintain a specific MLSS (mixed liquor suspended solids) concentration.
    b. A flow-through aeration system with biological sludge carry-over into the effluent.
    c. An intermittent aeration system with the clarified upper portion of the aeration basin contents being discharged directly to the river.[1]
3. Determine the quantity and characteristics of the excess biological sludge which must be disposed of.
4. Demonstrate the effectiveness of solids removal through the clarifier-thickener and disc filter handling system when operated:
    a. As straight silt removal system.
    b. With dewatering of secondary sludge in combination with silt.
    c. With dewatering of secondary sludge alone.
5. Demonstrate and establish operating parameters for the systems constructed and studied, which will include:

---

[1] This objective was to be pursued only if time permitted and it could be worked in conveniently.

a. Initial and construction costs.
b. Operating costs (power, chemicals, etc.).
c. Operation problems.
d. Treatment efficiency.
e. Maintenance problems and costs.
f. Silt and waste secondary sludge disposal problems and cost.

6. Determine the effect of this treatment on MPN and chlorine requirements of the final effluent.

7. Establish the influence of: foaming, ice, climatic temperatures, pH, nitrogen, phosphorus, and periodic flow interruptions and processing plant shutdowns upon the treatment system.

Operation and cost data included in this report are for the secondary treatment facility only. Primary treatment of the process wastewater is provided at the processing plant and has not been evaluated in this study.

The R. T. French Company retained the firm of Cornell, Howland, Hayes & Merryfield, Consulting Engineers, to design the facility and to exercise technical supervision over the research and development program.

SECTION IV
TREATMENT METHODS

ACTIVATED SLUDGE PROCESS

The activated sludge process is a biological treatment process in which biologically active growths (activated sludge) are continuously mixed in a basin with the wastewater in the presence of oxygen. The combination of wastewater and activated sludge is called mixed liquor. The oxygen is supplied to the mixed liquor from compressed air injected into the liquid mass in the form of fine bubbles under turbulent conditions, or by mechanical aeration. The activated sludge is subsequently separated from the mixed liquor by sedimentation in a clarifier and is then wasted or returned to the aeration basin as needed. The overflow from the clarifier (treated wastewater) is chlorinated and discharged to a receiving stream.

There are many variations of the activated sludge process; however, all operate basically the same. The variations are the result of unit arrangement and methods of introducing air and wastewater into the aeration basin.

The most recent advances in the activated sludge process utilize a "complete mix" approach when combining the activated sludge and wastewater. Biological stability and the subsequent efficiency of the aeration basin is enhanced by the design which maintains the entire content of the aeration chamber in a "completely mixed" and essentially homogeneous state during the aeration cycle. Wastewater introduced into the aeration basin is dispersed rapidly throughout the mass and is subjected to immediate attack by fully-developed organisms throughout the aeration basin.

Complete-mix activated sludge treatment may or may not be preceded by primary treatment. In general, large treatment facilities use primary treatment in conjunction with the activated sludge process, while smaller treatment plants do not.

The R. T. French treatment facility is a complete-mix system, preceded by primary treatment.

SOLIDS TREATMENT AND DISPOSAL

Unit processes currently employed in treatment and disposal of solids can be divided into four categories: concentration, stabilization, dewatering, and dehydration disposal. The R. T. French facility employs concentration, dewatering, and disposal methods as described below:

GRAVITY THICKENING–Gravity thickening is a concentration process in which solids are gently stirred in a sedimentation tank to release entrapped water and gas, allowing thickened solids to settle to a bottom hopper from which they are later removed.

VACUUM FILTRATION–Vacuum filtration is a dewatering process in which cylindrical drums or discs, covered with filter media and partially submerged in a container of sludge, rotate while a vacuum is pulled through the drum or disc surfaces and filter media. Water is extracted while solids are retained on the filter media to form a cake.

LANDFILL–Landfill is an ultimate process for disposing of dehydrated solids. It is, however, generally limited to reclaiming waste land.

SECTION V
THEORETICAL CONSIDERATIONS

BIOLOGICAL CHARACTERISTICS OF ACTIVATED SLUDGE

MICROBIOLOGY–The living organisms of activated sludge can be classified as plants and animals. The plants consist of bacteria and fungi, while the animals consist primarily of protozoa, rotifers, and nematodes.

Hawkes [1] stated that bacteria are normally dominant as primary feeders on organic wastes, with different holozoic protozoa being secondary feeders, and rotifers and nematodes being at the higher levels in the food chain. Fungi cannot normally compete with bacteria, but they may predominate as primary feeders if certain conditions exist, such as: low pH, nitrogen deficiency, or low dissolved oxygen [2]. High-carbohydrate wastes are also reported to stimulate fungi growth.

The composition of the organic waste determines which bacterial genera will predominate [1, 2]. Protein wastes favor *Alcaligenes, Flavobacterium, and Bacillus*, while carbohydrate wastes favors *Pseudomonas*. A high population of free swimming bacteria will sustain free swimming ciliata as the predominate protozoa; however, if the free swimming bacterial population is reduced, stalked cililates take over from the free swimming cililates because the lower food level cannot provide the amount of energy required by the free swimmers [2].

Rotifers thrive in very stable systems and are better indicators of stable conditions than are the nematode worms.

METABOLISM–The metabolic reactions which occur within activated sludge can be divided into three phases: (1) oxidation, (2) synthesis, and (3) endogenous respiration. These three phase reactions can be illustrated with the following general equations, which have been simplified from those formulated by Weston and Eckenfelder [3]:

(1) Organic Matter Oxidation

$$C_xH_yO_z + aO_2 \longrightarrow xCO_2 + bH_2O + \text{Energy}$$

(2) Cell Material Synthesis

$$C_xH_yO_z + NH_3 + cO_2 + \text{Energy} \longrightarrow C_5H_7NO_2 + dCO_2 + eH_2O$$

(3) Cell Material Oxidation

$$C_5H_7NO_2 + 5O_2 \longrightarrow 5CO_2 + 2H_2O + NH_3 + \text{Energy}$$

In the presence of enzymes, produced by living microorganisms, about one-third of the organic matter removed is oxidized to carbon dioxide and water to provide energy for synthesis of the other two-thirds of the organic matter removed to cell material [4]. The cell material is also oxidized to carbon dioxide, water, etc., by endogenous respiration (auto-oxidation).

KINETICS–Several authors [5,6,7] have formulated mathematical equations for design and operation of complete-mix activated sludge plants. Some of these formulations are more easily used for evaluation of full-sized plant operation than others. Eckenfelder's equations [6] are of this nature and have been used to evaluate the operation of the new R. T. French Company waste treatment facility. The basic equations are presented below:

SUBSTRATE UTILIZATION–The Michaelis-Menton relationship was used to define the microbial growth rate and steady state substrate removal in a completely mixed system, and a simplified equation for substrate removal was developed:

$$kS_e = \frac{S_a - S_f}{X_a t} = \frac{S_r}{X_a t}$$

where S_r = BOD removed, lbs per day
S_a = influent BOD, lbs per day
S_f = soluble effluent BOD, lbs per day
S_e = soluble effluent BOD, mg/l
X_a = average mixed liquor volatile suspended solids, lb
t = aeration time, days
k = removal rate coefficient, lb BOD/day-lb MLVSS-mg/l BOD

The equation shows that the substrate removal is proportional to the product of the MLVSS and the aeration time.

SLUDGE YIELD–Excess solids in the activated sludge system will result from the non-biodegradable suspended solids in the influent and the biological cells synthesized in the system during BOD removal less the quantity of cell mass synthesized which is broken down by endogenous respiration. This excess sludge can be expressed with the following equation, when influent non-volatile suspended solids do not exist or are ignored:

$$\Delta X_v = fS_o + aS_r - bX_d$$

where ΔX_v = net accumulation of volatile suspended solids, lbs per day

f = fraction of volatile suspended solids present in the influent which are not degradable

S_o = influent volatile suspended solids, lbs per day

a = sludge synthesis yield coefficient

S_r = BOD removed, lbs per day

b = rate of sludge endogenous respiration, per day

X_d = average mixed liquor volatile suspended solids which are degradable, lb

Where non-volatile suspended solids exist in the system influent, this quantity can be added directly to the foregoing excess solids yield, ΔX_v.

OXYGEN REQUIREMENTS–Oxygen is used to provide energy for synthesis of biological cells and for endogenous respiration of the biological mass. The total oxygen requirements can be expressed with the following equation:

$$O_2 = a' S_r + b' X_d$$

where O_2 = oxygen requirements, lbs per day

a' = fraction of BOD removed that is oxidized for energy

S_r = BOD removed, lbs per day

b' = oxygen used for endogenous respiration of the biological mass, per day

X_d = average mixed liquor volatile suspended solids that are degradable, lb

SECTION VI
PLANT DESCRIPTION

Potato processing plant wastewater can be divided into two major streams: (1) silt water and (2) process water. The silt water originates from raw potato washing and fluming operations. It contains large amounts of soil removed from the raw potatoes. Process water flows from potato processing operations, where raw potatoes are processed into packaged, partially cooked food products. It contains caustic potato peeler and barrel washer discharges, as well as all other liquid wasted from the processing operations, including cleanup water.

DESIGN CRITERIA

The criteria used for the final design of the secondary treatment facilities at the R. T. French Company are listed in Table 1.

TABLE 1
SECONDARY TREATMENT FACILITY DESIGN CRITERIA

AVERAGE DAILY FLOW			
Waste Process Water		1.0	
Waste Silt Water		0.25	
	TOTAL	1.25	mgd
PEAK HOUR FLOW RATE			
Waste Process Water		836	
Waste Silt Water		400	
	TOTAL	1,236	gpm
BOD LOAD			
Waste Process Water		13,700	
Waste Silt Water		400	
	TOTAL	14,100	lb/day
SUSPENDED SOLIDS LOAD			
Waste Process Water		5,680	
Waste Silt Water		940	
	TOTAL	6,620	lb/day

FLOW PATTERN

An aerial photo of the secondary waste treatment facility is shown on Figure 1, and the treatment facility flow diagram is shown on Figure 2. A general description of the flow patterns of the plant is given in the following paragraphs.

Primary clarified potato process wastewater flows by gravity to the influent pump pit where it is combined with clarified silt water. This total plant influent is then pumped to the aeration basin inlet-outlet structure, where the flow can be divided, as desired, between the two aeration basins. The incoming wastewater is dispersed throughout each of the aeration basins by floating mechanical aerators.

Effluent from the aeration basins flows by gravity back through the aeration basin inlet-outlet structure to the clarifier bypass structure. The flow is normally directed to the secondary clarifier, but in an emergency may be bypassed at the clarifier bypass structure for discharge to the Snake River.

Effluent from the secondary clarifier flows to the Snake River.

Lightweight settled sludge flows by gravity from the bottom of the clarifier to the sludge collection launder. It then flows by gravity from the sludge launder to the sludge recirculation pump pit. The sludge is then pumped to the recirculated sludge splitter box, where it can be divided into two portions of desired size and returned to the two aeration basins.

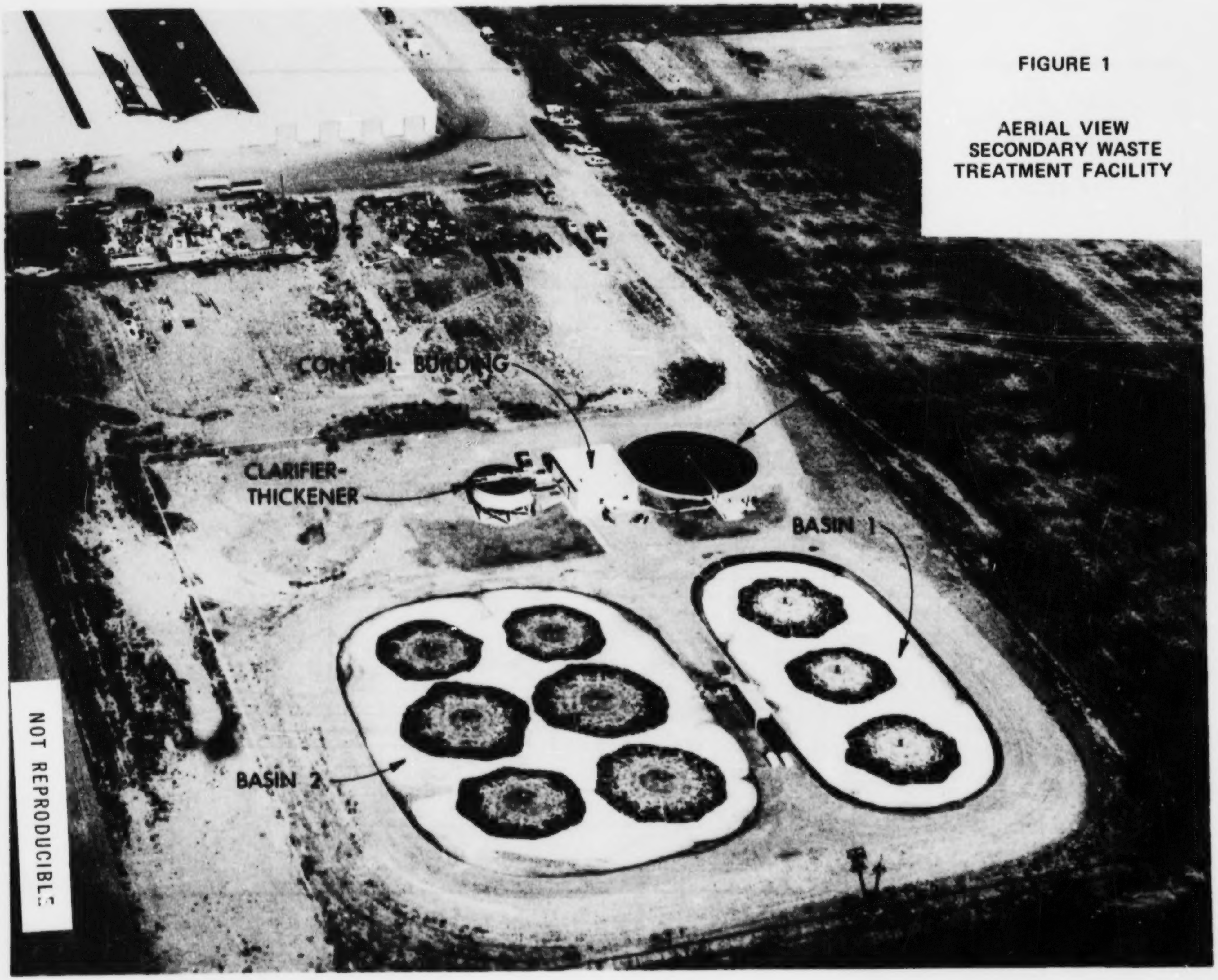
Dense settled sludge is pumped from the sludge hopper in the bottom of the clarifier to either the vacuum filter or to the clarifier-thickener. This waste sludge may also be pumped to the clarifier bypass structure for discharge to the river.

The waste sludge, pumped to the clarifier-thickener, is concentrated along with silt water. Clarifier-thickener overflow is transferred by gravity to the influent pump pit. The thickened sludge is pumped from the bottom of the clarifier-thickener to the vacuum filter, where it is dewatered along with any waste sludge pumped directly to the filter.

Solids discharge from the vacuum filter is conveyed to the silt bunker in a cake form. This cake is then hauled away by trucks for ultimate disposal as landfill.

FIGURE 1

AERIAL VIEW
SECONDARY WASTE
TREATMENT FACILITY


CONTROL BUILDING
CLARIFIER-
THICKENER
BASIN 1
BASIN 2

NOT REPRODUCIBLE

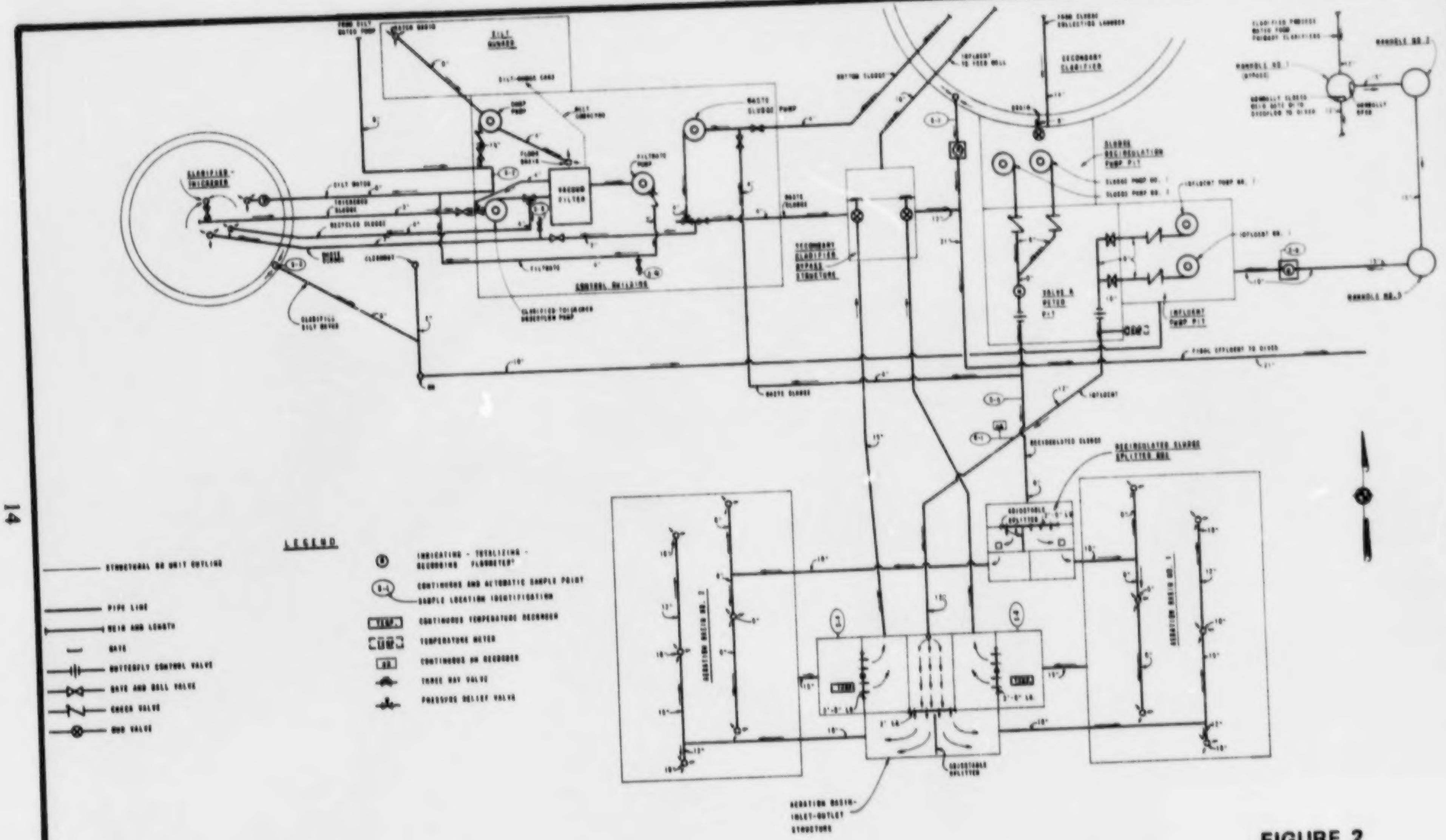

LEGEND
STRUCTURAL OR UNIT OUTLINE
PIPE LINE
WEIR AND LENGTH
GATE
BUTTERFLY CONTROL VALVE
GATE AND BALL VALVE
CHECK VALVE
PLUG VALVE
INDICATING - TOTALIZING - RECORDING FLOWMETER
CONTINUOUS AND AUTOMATIC SAMPLE POINT
SAMPLE LOCATION IDENTIFICATION
CONTINUOUS TEMPERATURE RECORDER
TEMPERATURE METER
CONTINUOUS pH RECORDER
THREE WAY VALVE
PRESSURE RELIEF VALVE
CLARIFIER-THICKENER
SILT WATER
THICKENED SLUDGE
RECYCLED SLUDGE
WASTE SLUDGE
CLEANOUT
CLARIFIED SILT WATER
FROM SILT WATER PUMP
SILT BUNKER
SUMP PUMP
FLOOR DRAIN
VACUUM FILTER
FILTRATE PUMP
FILTRATE
CONTROL BUILDING
WASTE SLUDGE PUMP
SECONDARY CLARIFIER BYPASS STRUCTURE
INFLUENT TO FEED WELL
SECONDARY CLARIFIER
DRAIN
SLUDGE RECIRCULATION PUMP PIT
SLUDGE PUMP NO. 1
SLUDGE PUMP NO. 2
INFLUENT NO. 1
VALVE & METER PIT
INFLUENT PUMP PIT
FINAL EFFLUENT TO RIVER
MANHOLE NO. 1 (BYPASS)
MANHOLE NO. 2
MANHOLE NO. 3
INFLUENT
RECIRCULATED SLUDGE
RECIRCULATED SLUDGE SPLITTER BOX
ADJUSTABLE SPLITTER
AERATION BASIN NO. 1
AERATION BASIN NO. 2
AERATION BASIN INLET-OUTLET STRUCTURE

FIGURE 2

FLOW DIAGRAM
SECONDARY WASTE
TREATMENT FACILITY

DESIGN FACTORS

The design factors used for major equipment selection are shown in Table 2. Photographs of the major components are located in Appendix B and the major treatment units are described below. Selected equipment manufacturers are listed in Table 3.

Aeration Basin 1 holds 1.25 million gallons and normally contains three 50-hp foating mechanical aerators. Aeration Basin 2 holds 2.5 million gallons and normally utilizes six 50-hp floating mechanical aerators. Both basins have a water depth of 16 feet. The design BOD loading is 28 lb/1,000 cu ft/day when the two aeration basins are operated in parallel. The aeration basins are constructed of earth and were lined with PVC (polyvinyl chloride). The bottom of the basins were sloped to prevent forming pockets for entrapment of water or gas. A sun-resistant Hypalon plastic sheet was placed around the perimeter of the basins to protect the PVC from exposure to sunlight. The Hypalon was bonded to the PVC to provide a watertight field weld.

The secondary clarifier is 70 feet in diameter and has a 12-foot side water depth. The clarifier has a rapid sludge withdrawal mechanism. The hydraulic overflow rate is 325 gal/sq ft/day at the design flow of 1.25 mgd.

The treatment facility control building houses the vacuum filter, sampling and testing laboratory, and various sludge handling equipment. The vacuum filter is a disc type and has a surface area of 300 square feet.

The clarifier-thickener is 30 feet in diameter and has a side water depth of 8 feet. The hydraulic overflow rate at design flow is 860 gal/sq ft/day.

TABLE 2
SECONDARY TREATMENT FACILITY DESIGN FACTORS

INFLUENT PUMPS	
Number	2
Type	Centrifugal
Capacity	
Each	1,300 gpm
Total	2,600 gpm
Total Head	27 feet
Constant Speed	870 rpm

TABLE 2 - CONTINUED

SLUDGE RECIRCULATION PUMPS	
Number	2
Type	Centrifugal
Capacity	
Each	435 gpm
Total	870 gpm
Total Head	18 feet
Constant Speed	870 rpm
WASTE SLUDGE PUMP	
Number	1
Type	Positive displacement
Capacity	100 gpm
Total Head	46 feet
Speed	550 rpm
Drive	Variable - speed
AERATION BASINS	
Number	2
Type	Earthen
Volume of Basin 1	1.25 million gallons
Volume of Basin 2	2.5 million gallons
Basin Water Depths	16 feet
Basin Side Slopes	2:1
Basin Freeboard	2 feet
Basin Lining	PVC with Hypalon cover in sun-exposed area
Number of Aerators, Basin 1	3
Number of Aerators, Basin 2	6
Design Organic loading	28 lb BOD/1,000 cu ft/d
AERATION EQUIPMENT	
Number Aerators in Aeration Basins	9
Type	Floating pump type mechanical surface aerators with variable oxygen transfer-power draw feature

TABLE 2 - CONTINUED

AERATION EQUIPMENT - Continued	
Oxygen Transfer Capacity	75 pounds per hour each in aeration basins with mixed liquor suspended solids = 4,000 mg/l, operating elevation = 4,627 ft. above MSL, temperature at 20 degrees C., Alpha = 0.85, Beta = 0.90, and operating dissolved oxygen = 1.5 mg/l
SECONDARY CLARIFIER	
Number	1
Diameter	70 feet
Side Water Depth	12 feet
Mechanism Type	Multiple port hydraulic suction
Design Flow	1.25 million gallons/day
Overflow Rate at Design Flow	325 gal/sq ft/day
Detention Time at Design Flow	7.2 hours
CLARIFIER-THICKENER	
Number	1
Diameter	30 feet
Side Water Depth	8 feet
Design Flow	425 gpm
Overflow Rate at Design Flow	860 gal/sq ft/day
VACUUM FILTER STATION	
Vacuum Filter	
Number	1
Type	Disc
Diameter	6 feet
Number of Discs	6
Filter Area	300 square feet
Tank Volume	750 gallons
Hydraulic Capacity - Filtrate	150 gpm
Vacuum Pump	
Number	1
Capacity	900 cfm
Speed	2,100 rpm
Vacuum	20 inches Hg

TABLE 2 - CONTINUED

VACUUM FILTER STATION - Continued	
Filtrate Pump	
Number	1
Capacity	150 gpm
Speed	1,750 rpm
Allowable Head	55 feet
Blower	
Number	1
Capacity	199 cfm
Speed	1,750 rpm
Discharge Pressure	5 psi
Screw Conveying System	
Size of Screw	9 inches
Length	27 feet
Capacity	200 pounds per hour
Clarifier-Thickener Underflow Pump	
Number	1
Type	Diaphram
Capacity	50 gpm
Total Head	30 feet
Power Unit	Variable drive

TABLE 3
MAJOR EQUIPMENT MANUFACTURER

EQUIPMENT ITEM	MANUFACTURER
Influent pumps	Cornell Manufacturing Co.
Sludge recirculation pumps	Chicago Pump Co.
Waste sludge pumps	Moyno Pumps
sample pumps	Robbins & Meyers, Inc.
Clarifier-thickener underflow pump	Marlow Pumps
Flowmeters	Hersey-Sparling Meter Co.
Aerators	Welles Products Corp.
Disc filter	Eimco Corporation
clarifier-thickener mechanism	
Secondary clarifier mechanism	Dorr-Oliver, Inc.

DEMONSTRATION PROCEDURES

During the test period, the secondary treatment facility received wastewater flow on a schedule parallel with the operating schedule of the potato processing plant. The processing plant operated almost continuously, except for a two-day shutdown on weekends for cleanup and repairs. Cleaning water flow during processing shutdowns was directed to the treatment facility.

Primary clarified process wastewater was directed to the secondary treatment facility by adjusting slide gates in Manhole 1 (see Figure 2). The amount of process water discharged to the facility was determined by the aeration basin operation. All process water entered the facility during normal operation. Screened silt water was directed to the clarifier-thickener by silt water pumps in the storage cellars.

Potato processing seasons are about nine to ten months long in Idaho.

OPERATION SCHEDULE–The secondary waste treatment facility was operated from 3 September 1969 through 6 June 1970. The activated sludge system was operated as shown in Table 4.

AERATION BASIN STARTUP–Initial startup of the activated sludge system included: (1) filling aeration basin 2 with wastewater, (2) aerating the wastewater without additional influent until the D. O. rose above 0.5 mg/l, (3) directing increased portions of the total plant influent to the aeration basin while maintaining the D. O. above 0.5 mg/l, and (4) returning all of the secondary clarifier solids to the aeration basin until the desired MLSS concentration was reached.

After initial plant startup, aeration basins have been restarted by transferring some or all of the contents of the basin in operation into the basin being started. Influent wastewater was then directed to the newly started basin in increasing proportions of the total plant influent while maintaining a residual D. O. concentration over 0.5 mg/l. All of the secondary clarifier solids were returned until the desired MLSS concentration was attained.

The startup method used successfully during the latter part of the demonstration period and during the current processing season includes the following steps:

1. Fill the basin with clean water.

2. Position and start aerators.

TABLE 4

ACTIVATED SLUDGE SYSTEM OPERATION SCHEDULE

OPERATION PERIOD	BASIN NO.	METHOD OF OPERATION	% OF INFLOW	AVERAGE FLOW (MGD)	AVERAGE DETENTION TIME (DAYS)	LENGTH OF OPERATION (DAYS)	MLSS[1] OPERATING RANGE (MG/L)	BASIN TEMP. OPERATING RANGE (^{o}F)
SEPT. 3 TO OCT. 22	2	R.S.[2]	100	0.530	4.71	50	930–3600	46–67
OCT. 22 TO NOV. 10	1	R. S.	20	0.241	5.18	19	66–6280	50–68
	2	R.S.	80	0.967	2.58		1830–6130	55–67
NOV. 10 TO DEC. 18	1	R.S.	33	0.341	3.66	36	2350–5140	45–63
	2	R.S.	67	0.694	3.60		1830–6450	45–61
DEC. 18 TO JAN. 12	1	R.S.	20	0.207	6.03	25	1430–3360	42–50
	2	F.T. [3]	80	0.829	3.01		1350–4050	49–58
JAN. 12 TO FEB. 12	2	R.S.	100	0.717	3.48	31	245–3270	43–60
FEB. 12 TO APR. 13	1	R.S.	100	1.144	1.09	60	455–9400	45–65
APR. 13 TO MAY 27	2	R.S.	100	1.071	2.33	45	1450–7100	50–70
MAY 27 TO JUNE 6	1	F.T.	22.5	0.197	6.34	9	450–2750	50–60
	2	R.S.	77.5	0.681	3.67		1100–3600	60–68

NOTES:

(1) MIXED LIQUOR SUSPENDED SOLIDS
(2) RETURN SLUDGE AERATION
(3) FLOW THROUGH AERATION

3. Build up a D. O. of about 5 mg/l in the basin.

4. Start feeding wastewater to the basin at increasing flow rates as the MLSS concentration increases. Keep the F:M ratio (pounds of BOD per day to the pounds of mixed liquor volatile suspended solids in the basin) between 0.1 and 0.5 in accordance with Figure 3.

5. Keep the D. O. level above 1.0 mg/l at all times, preferably in the range of 1.5 to 3.0 mg/l.

6. Return all secondary clarifier solids to the aeration basin until the desired MLSS level is reached.

Future processing plant annual startups will be by stages, permitting treatment of the entire wastewater flow by the secondary treatment facility.

SAMPLING SCHEDULE AND PROCEDURE–Sample points are shown on Figure 2 and are described in detail in Appendix D. Waste activated sludge and vacuum filter filtrate analyses were made on grab samples. Samples were collected at all other sample points with sample pumps and automatically controlled stock samplers to give 24-hour composite samples, proportional to flow.

The sampling and testing schedule used during the demonstration operation is located in Appendix D.

ANALYTICAL TECHNIQUES–Analytical tests were performed in accordance with the twelfth edition (1965) of *Standard Methods for the Examination of Water and Wastewater* of the American Public Health Association, with the following exception:

Suspended Solids–Suspended solids tests were performed using GF/C glass-fiber filter discs instead of asbestos mats. A list of the laboratory equipment used in the analytical testing is included in Appendix D.

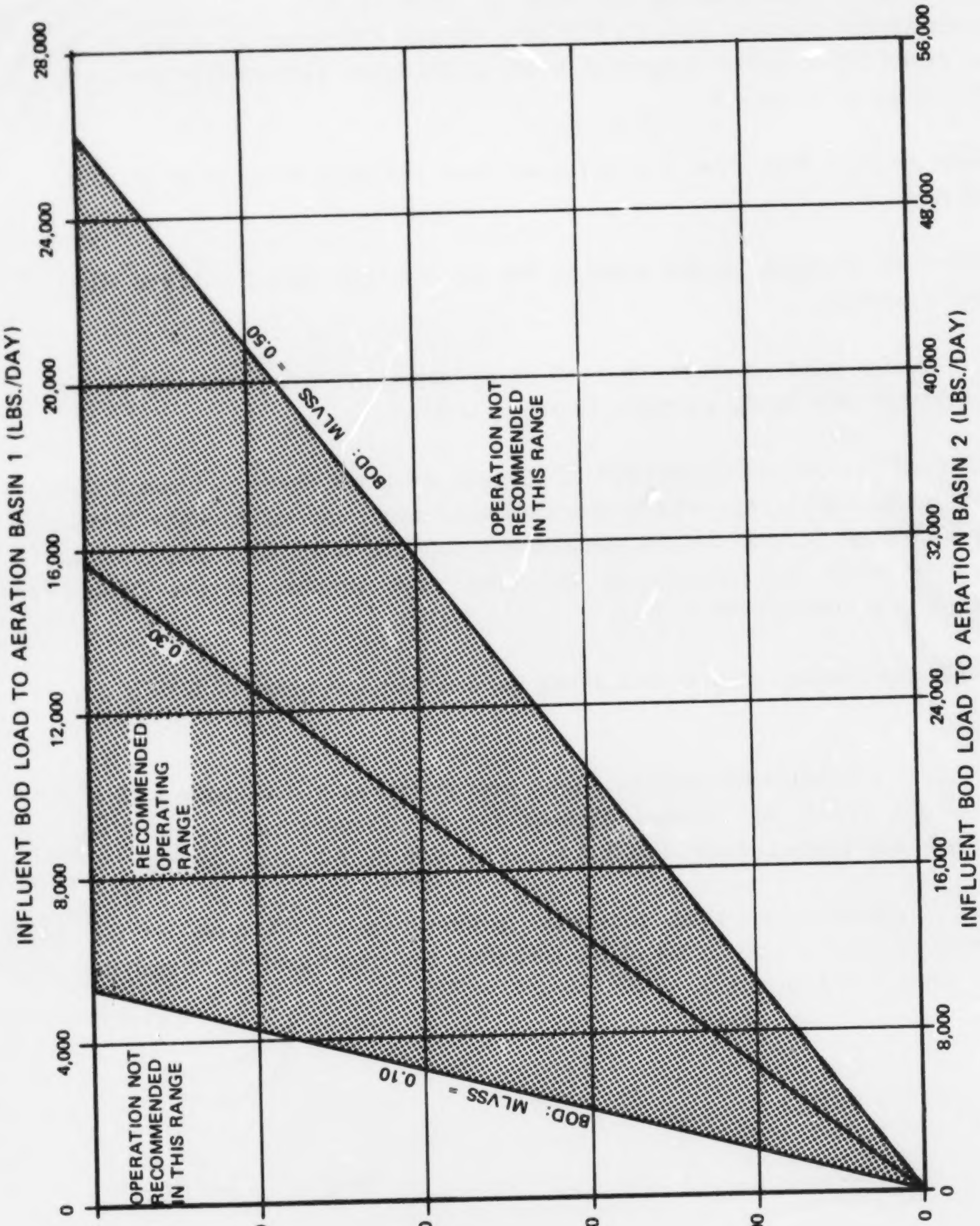


FIGURE 3

AERATION BASIN OPERATION

SECTION VII
PLANT INFLUENT CHARACTERISTICS

Total secondary treatment plant influent contains primary clarified process water and clarified silt water. Characteristics of the total plant influent are described below, and daily variations and probability plots of the characteristics are located in Appendix C.

ALKALINITY, pH, AND TEMPERATURE–Total plant influent alkalinity varied from 70 mg/l to 5,740 mg/l, with an average of 1,640 mg/l, as $CaCO_3$. The pH varied from 6.8 to 11.5, and averaged 9.3. The influent temperature varied from 12 degrees C to 24 degrees C. The average temperature was 20 degrees C.

BOD AND COD–The BOD of the total plant influent varied from 780 mg/l to 3,210 mg/l. The average BOD was 1,680 mg/l. Sixty-five to 70 percent of the total influent BOD was in a soluble form. The total BOD loading varied from 385 lbs/day to 33,000 lbs/day, with an average of 14,500 lbs/day. Figure 4 shows the average weekly BOD load variation and the general tread of increased load (first order curve, least squares fit) as the processing season progressed. The COD (chemical oxygen demand) of the influent varied from 1,330 mg/l to 7,100 mg/l, with an average of 3,050 mg/l. The average influent BOD:COD ratio was 0.55.

SUSPENDED SOLIDS–The TSS (total suspended solids) concentration in the total plant influent varied from 320 mg/l to 6,460 mg/l. The average TSS was 1,480 mg/l. VSS (volatile suspended solids) averaged 70 percent of the TSS.

NUTRIENTS–The BOD:nitrogen:phosphate ratio of the plant influent varied from 100:4.4:0.6 to 100:10.1:2.4 and averaged 100:6.2:1.1.

FLOW–The total plant influent flow varied from 0.03 mgd to 1.64 mgd and averaged 0.95 mgd.

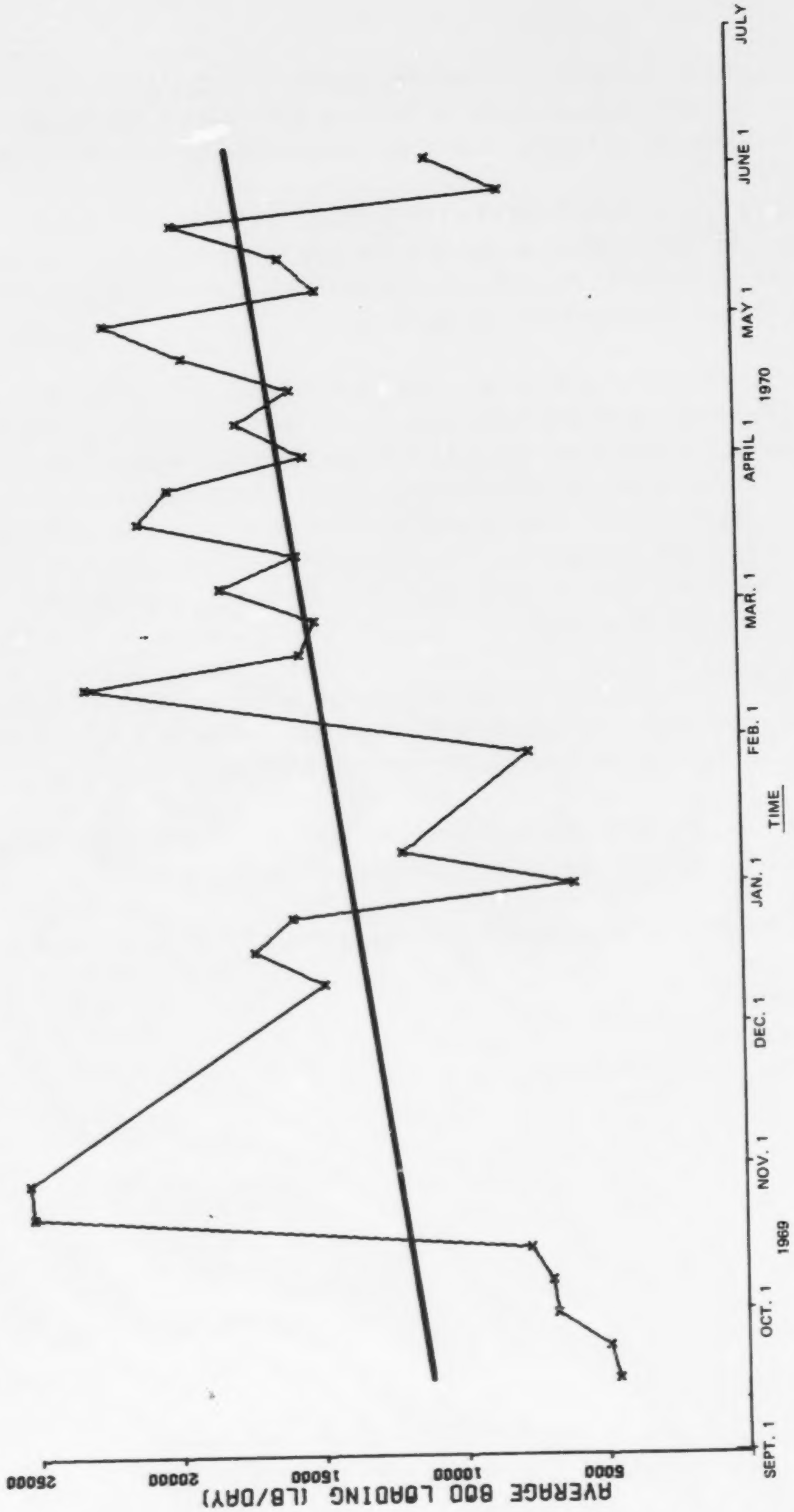


FIGURE 4

AVERAGE BOD LOADING VS. TIME
(ALL DATA)

SECTION VIII
PLANT PERFORMANCE

ACTIVATED SLUDGE SYSTEM

SYSTEM OPERATION–Numerous mechanical problems hindered plant performance; however, four months of effective operation has been achieved. The operating data from these four months of experience have been analyzed in greater detail than the data for the other five months of demonstration operation.

Figure 5 is a computer plot of the best fit curve of the frequency distribution of BOD loading to the activated sludge system on arithmetic-probability paper. The probability shown on this and following similar figures is the percentage of measurements equal to, or less than, the stated class mean of the measured item, with all available data being used. Figure 5 shows that about 45 percent of the time the BOD loading to the activated sludge system was equal to, or less than, the plant design load of 14,100 lbs BOD/day or 55 percent of the time, the BOD loading was equal to, or greater than, the design load. Actual loadings exceed the design criteria because of a delay in the construction of the facility and an expansion of the processing plant. However, design safety factors permit the present treatment plant to handle the existing volume of processing wastes; although further expansion of the processing plant capacity could require expansion of treatment facilities.

Aeration basin dissolved oxygen levels are shown on Figure 6. Figure 7 shows that about 40 percent of the time the D. O. (dissolved oxygen) in Basin 1 was less than 1.0 mg/l, which is often thought to be a minimum level to avoid limiting biological activity. Basin 2 operated at a similar level for over 25 percent of the time (Figure 8). Low basin D. O. levels were associated with mechanical aerator problems. At the top of Figure 6 and subsequent plots with time functions, R. S. means return sludge operation and F. T. means flow-through operation. The percentages represent the portion of influent to each basin.

The temperature variations in the aeration basins are shown on Figure 9, while Figure 10 shows that about 20 percent of the time, Basin 1 temperature was equal to, or below, 50 degrees F (10 degrees C), which is reported to be low enough for filamentous bacteria to become competitive. Basin 2 had similar low temperatures 10 percent of the time (Figure 11). Low basin temperatures occurred at long aeration times and low air temperatures. Basin temperatures also dropped during weekend shutdowns when warm process water discharges to the treatment facility were decreased or discontinued.

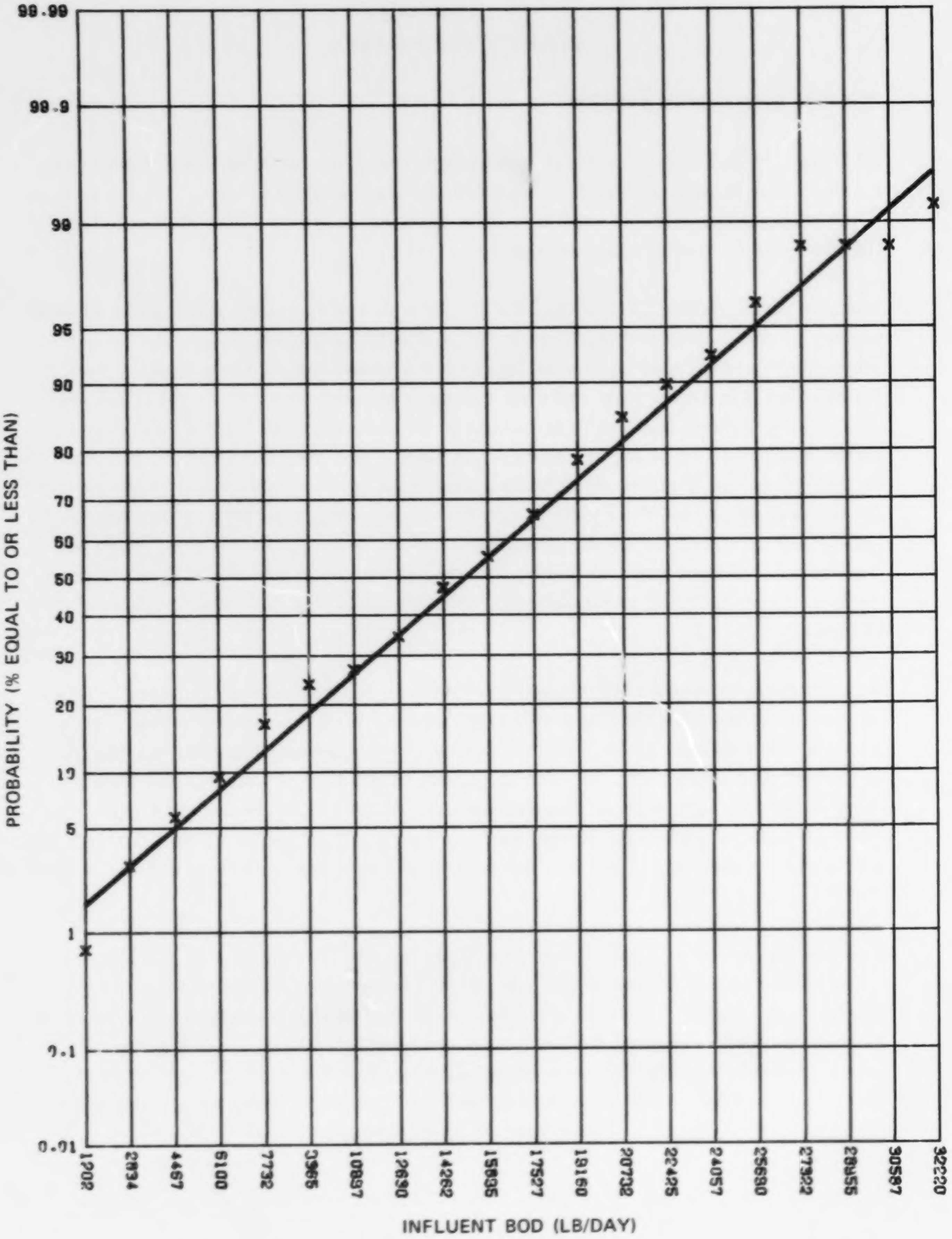


FIGURE 5

PROBABILITY OF INFLUENT BOD

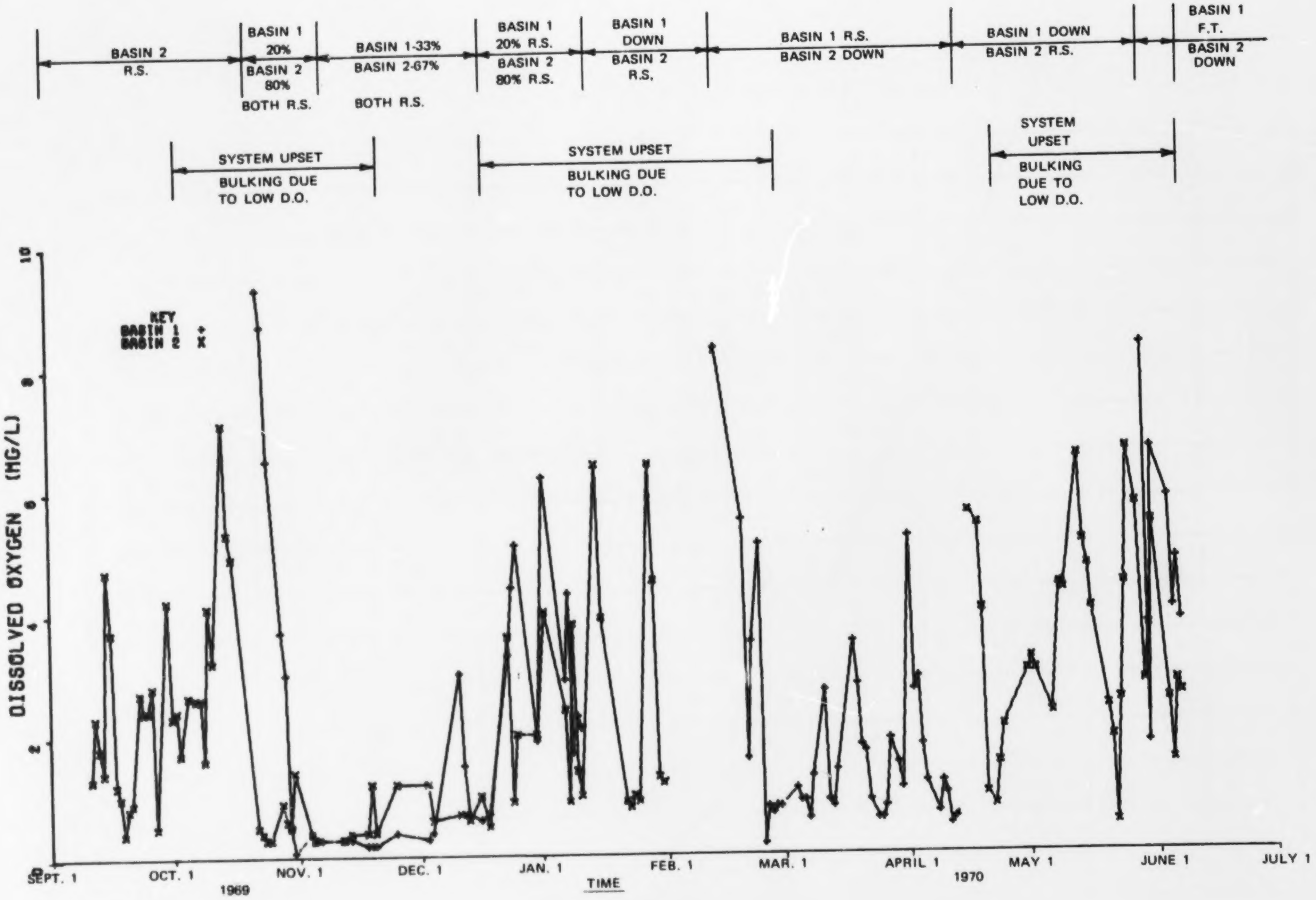


FIGURE 6

AERATION BASIN DISSOLVED OXYGEN
(ALL DATA)

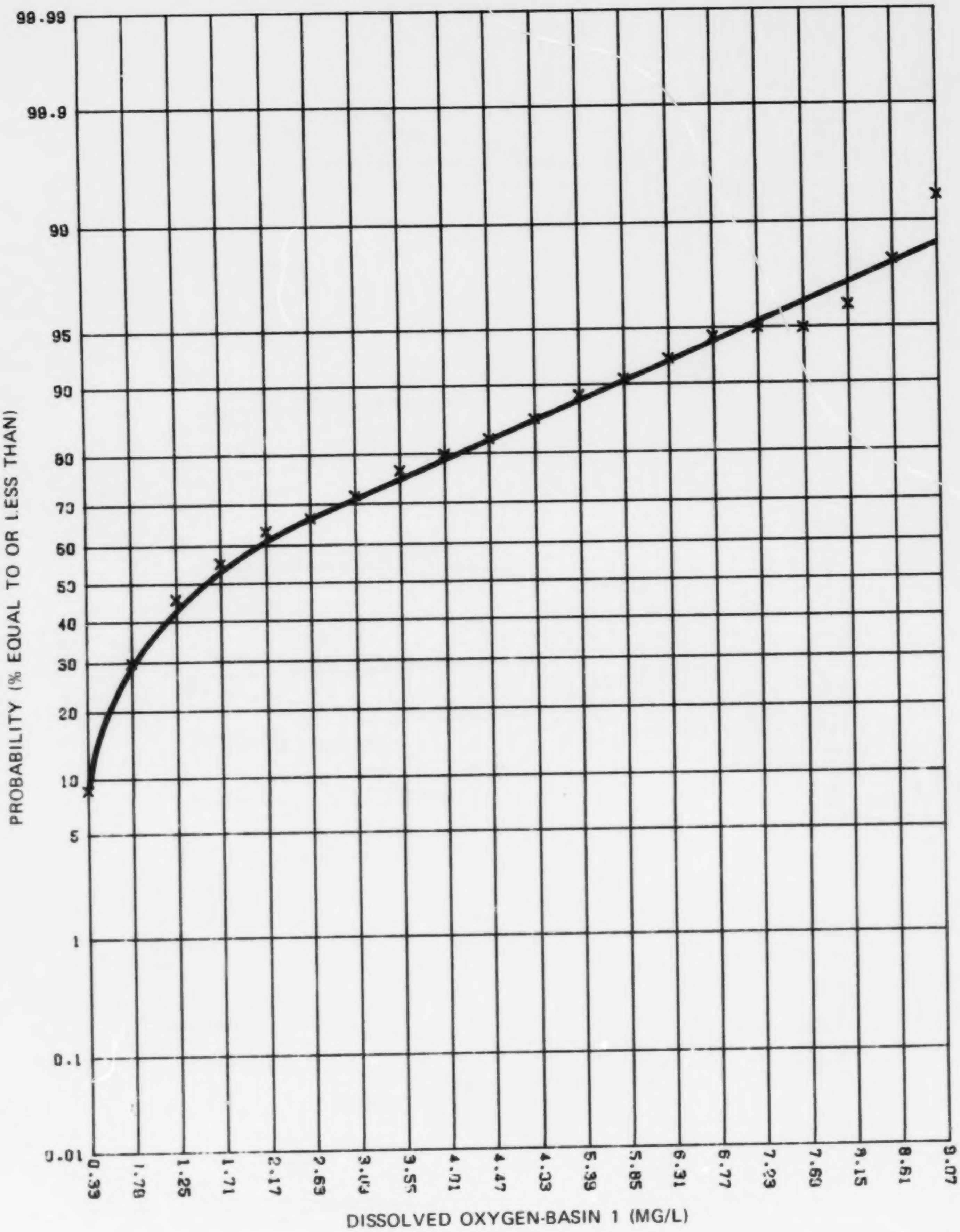


FIGURE 7

PROBABILITY OF DISSOLVED OXYGEN – BASIN 1

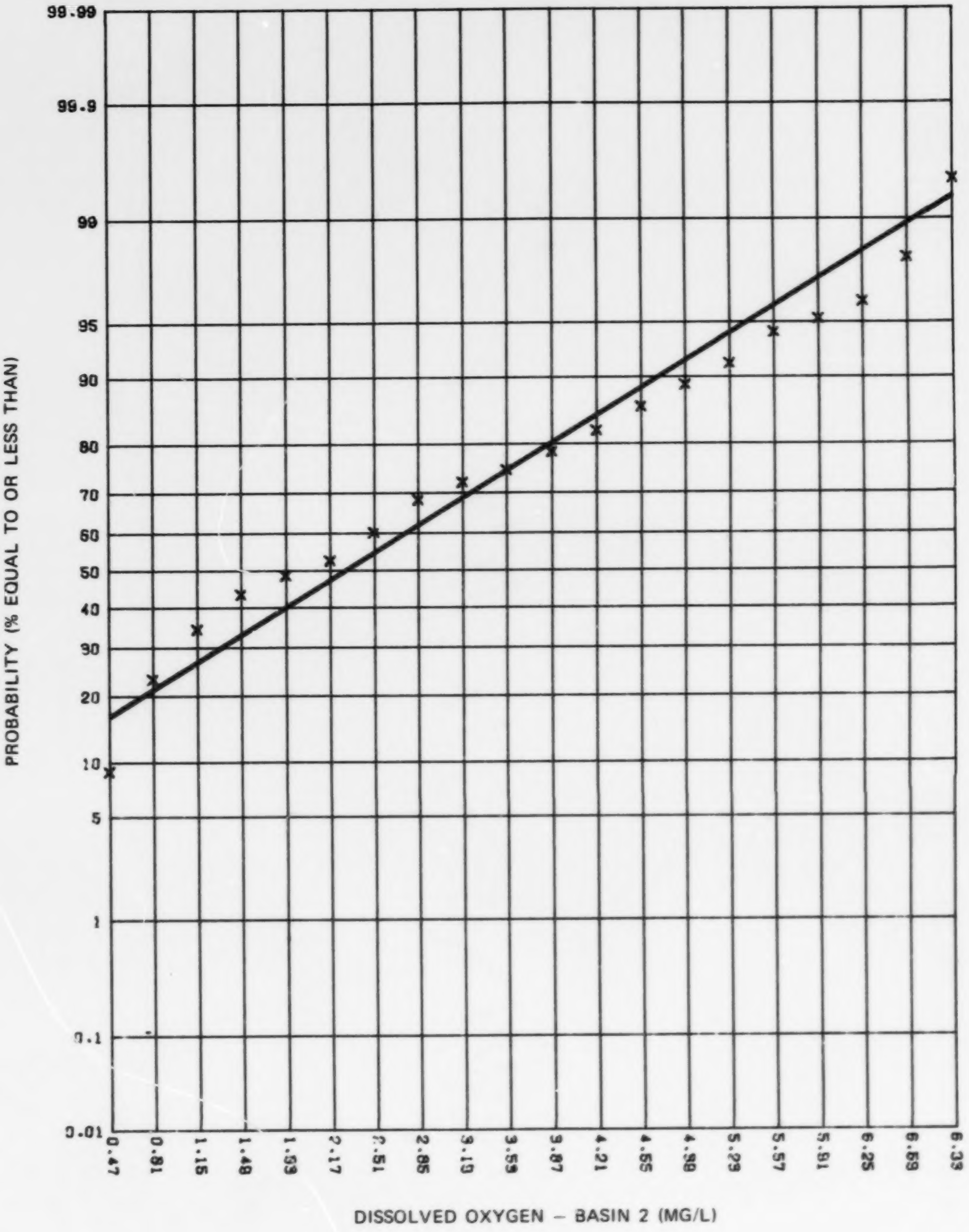


FIGURE 8

PROBABILITY OF DISSOLVED OXYGEN – BASIN 2

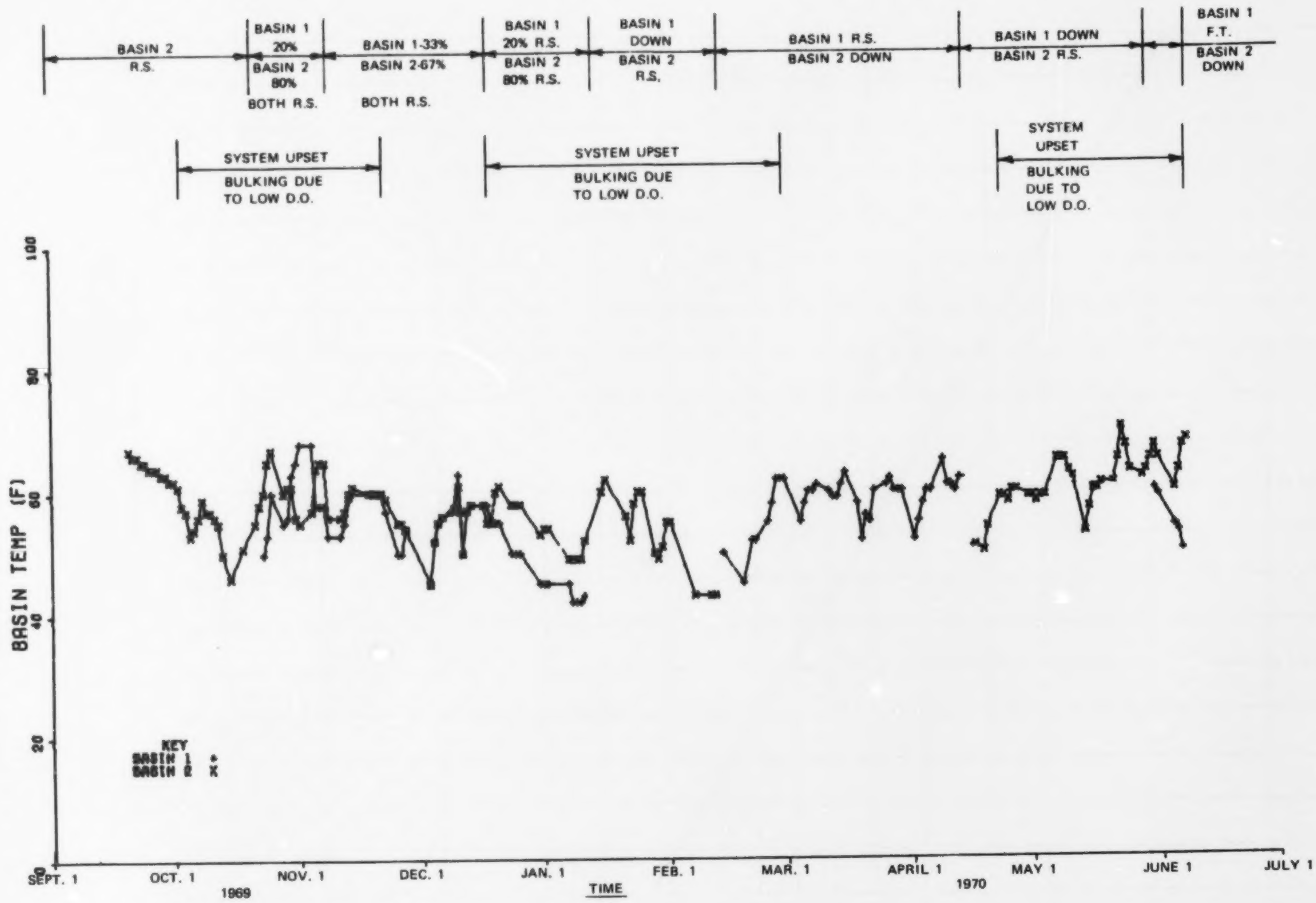


FIGURE 9

BASIN TEMP. VS. TIME
(ALL DATA)

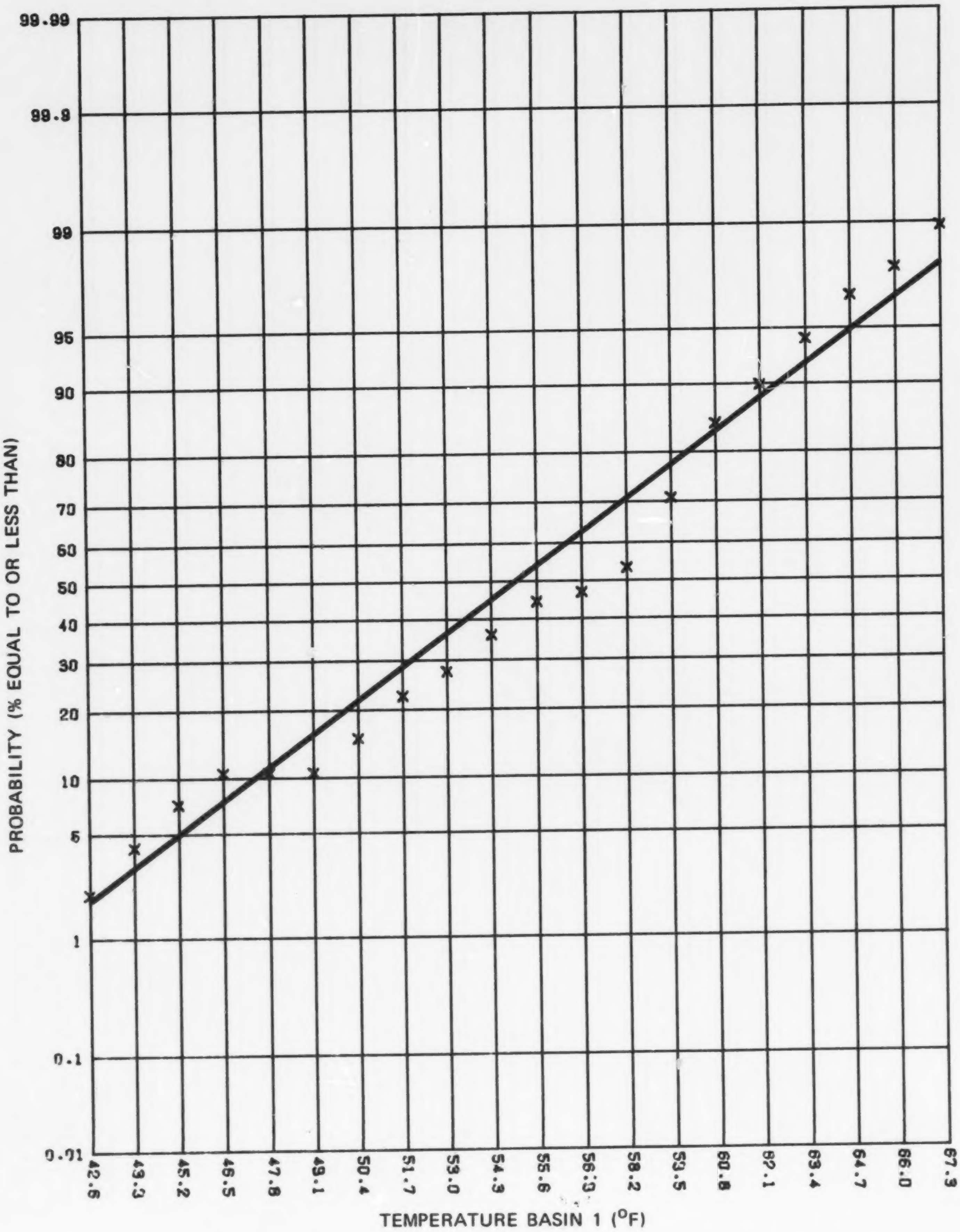


FIGURE 10

PROBABILITY OF TEMPERATURE – BASIN 1

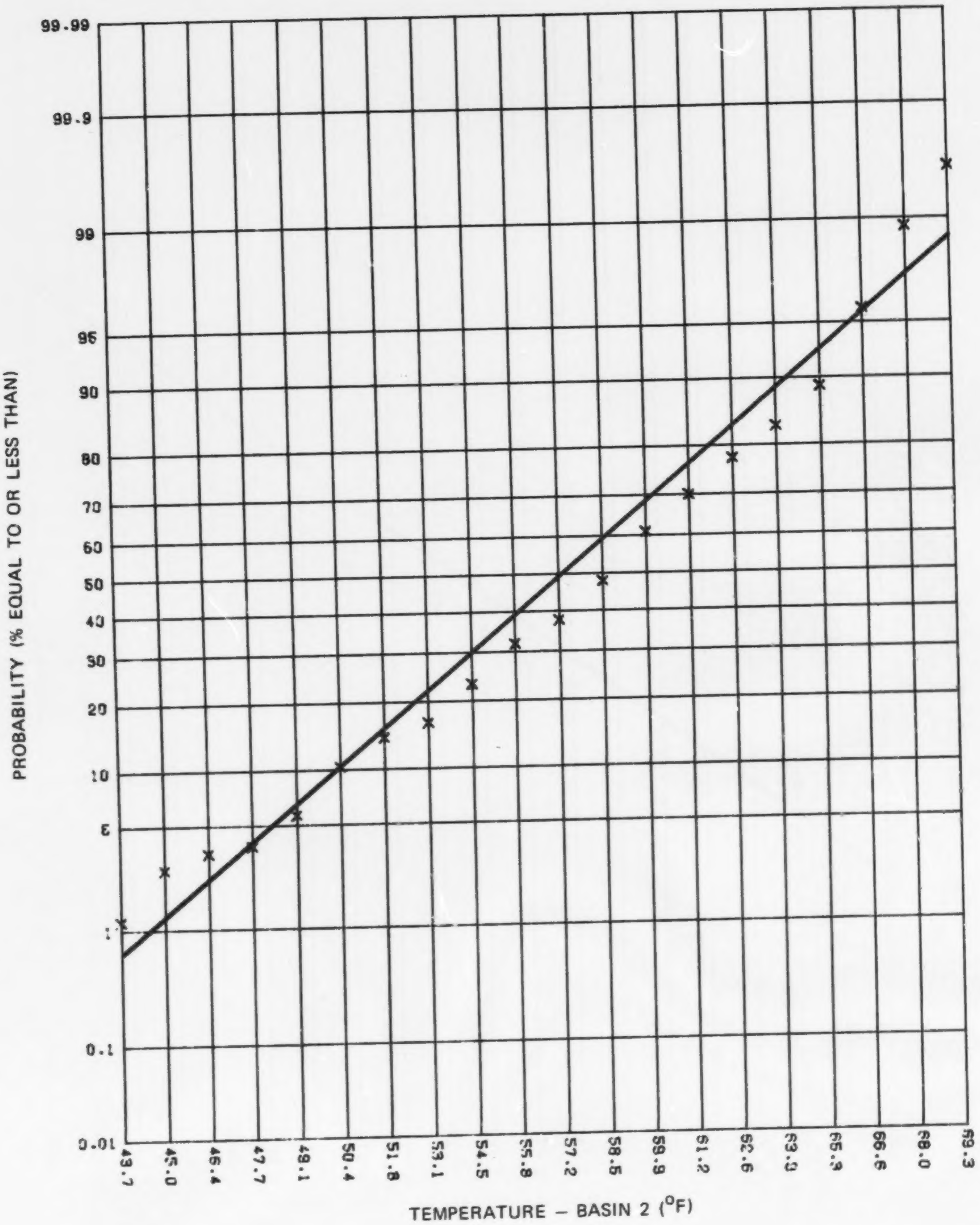


FIGURE 11

PROBABILITY OF TEMPERATURE – BASIN 2

Aeration basin pH variations are shown on Figure 12. Figure 13 shows that about 35 percent of the time, the pH of Basin 1 was equal to, or above, 8.0, which is normally considered the top of the normal operating range for an activated sludge system. This occurred in Basin 2 about 25 percent of the time (Figure 14), but neither basin appeared to be directly affected by the high pH.

CO_2 production in the aeration basins during organic material breakdown buffered the high alkalinity in the influent and resulted in a pH drop. This is illustrated on Figure 15. The average influent pH was 9.3 and the average effluent pH was 7.8. Many of the high basin pH levels were associated with low values of organic removal, which were caused by mechanical aerator problems.

The aeration basin SVI (sludge volume index) variations are shown on Figure 16. SVI levels above 200 correspond to sludge bulking and corresponding reduced process efficiencies.

Influent and effluent BOD variations are shown on Figure 17. Figure 18 shows that weekly average BOD and COD reductions decreased during periods of sludge bulking. Sludge bulking was associated with mechanical aerator failures, which lowered the available D. O. in the aeration basins below desirable levels.

Figure 19 shows that the BOD removal was 82 percent, or greater, 50 percent of the time. The average BOD removal for the entire demonstration period was 80 percent, even though numerous mechanical problems limited operating efficiency much of the time.

Analysis of three periods of effective operation, two about one month long each, and one about two months long, with the plant operating as a return sludge activated sludge system, has provided several operating relationships. These relationships are described hereinafter and are based on weekly average data unless noted otherwise. The three periods of optimum operation, analyzed in detail, were: 14 September - 4 October, 23 November - 20 December, and 1 March - 22 April. The referenced figures include least-square curves fitted to the plotted data by computer. Figures without average data reference are plotted from available daily data.

The effect of average BOD loading (lb BOD/lb MLVSS/day) on percentage of BOD removal is shown on Figure 20. Figure 21 shows the effect of this same BOD loading on effluent BOD concentration. As the BOD loading increased, the effluent BOD appeared to increase, while the BOD removal remained above 94 percent. Figure 22 shows substrate removal [(influent BOD - effluent soluble BOD)/influent BOD] versus BOD loading for all data. Substrate removal was above 90 percent during the entire demonstration period, including sludge bulking periods, and effluent soluble BOD remained below 125 mg/l (Figure 23).

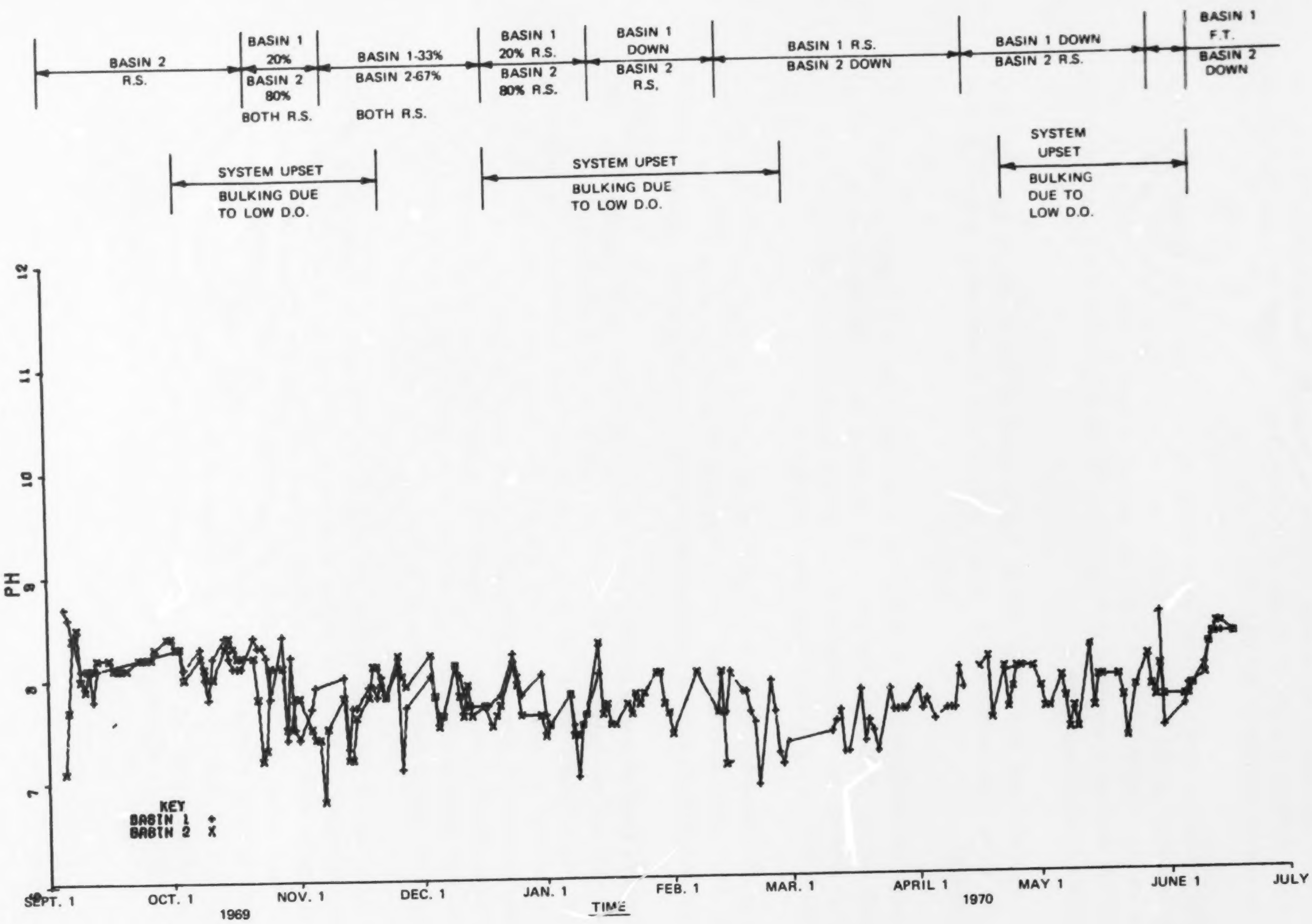


FIGURE 12

BASIN pH VS. TIME
(ALL DATA)

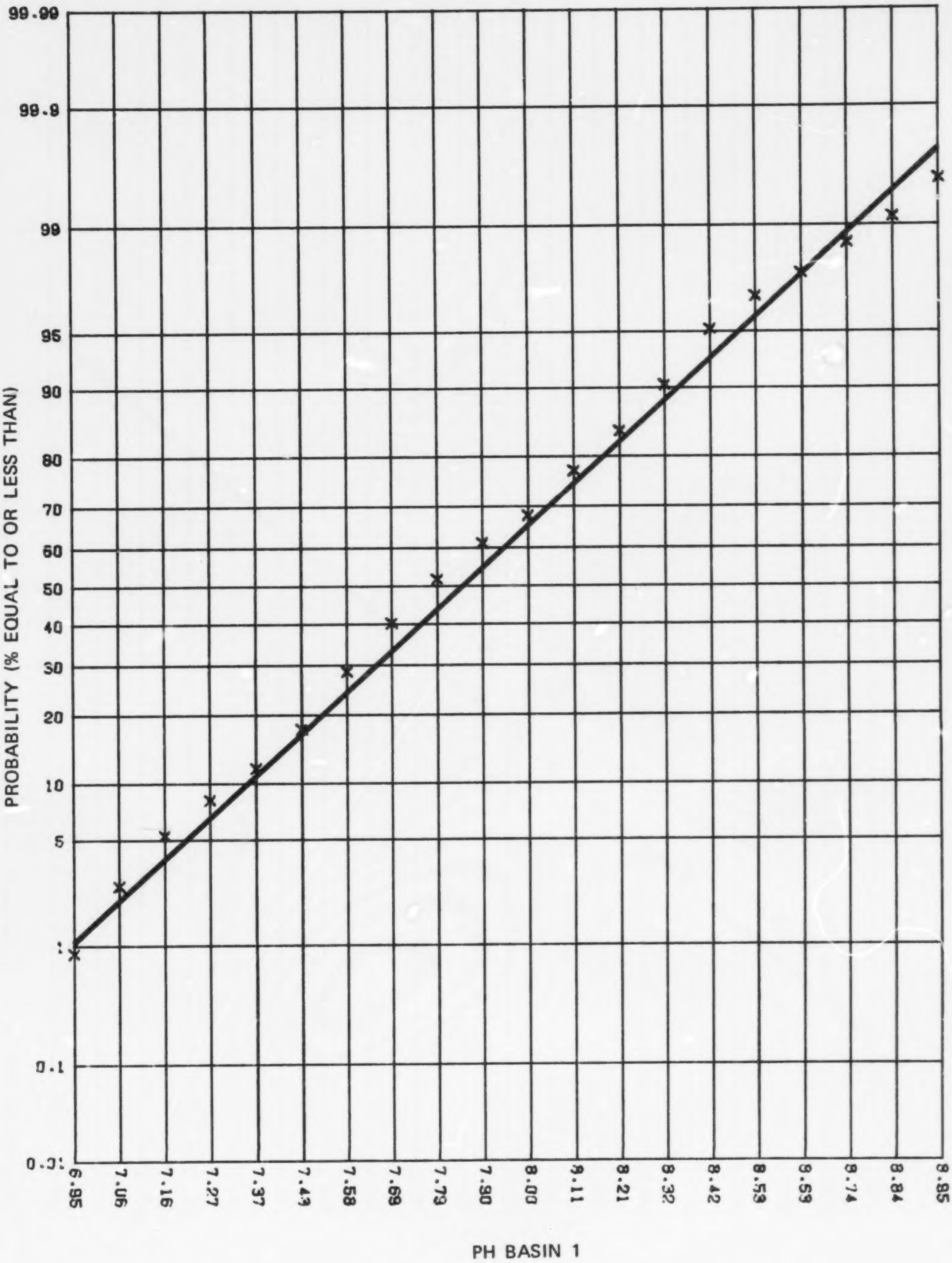


FIGURE 13

PROBABILITY OF pH BASIN 1

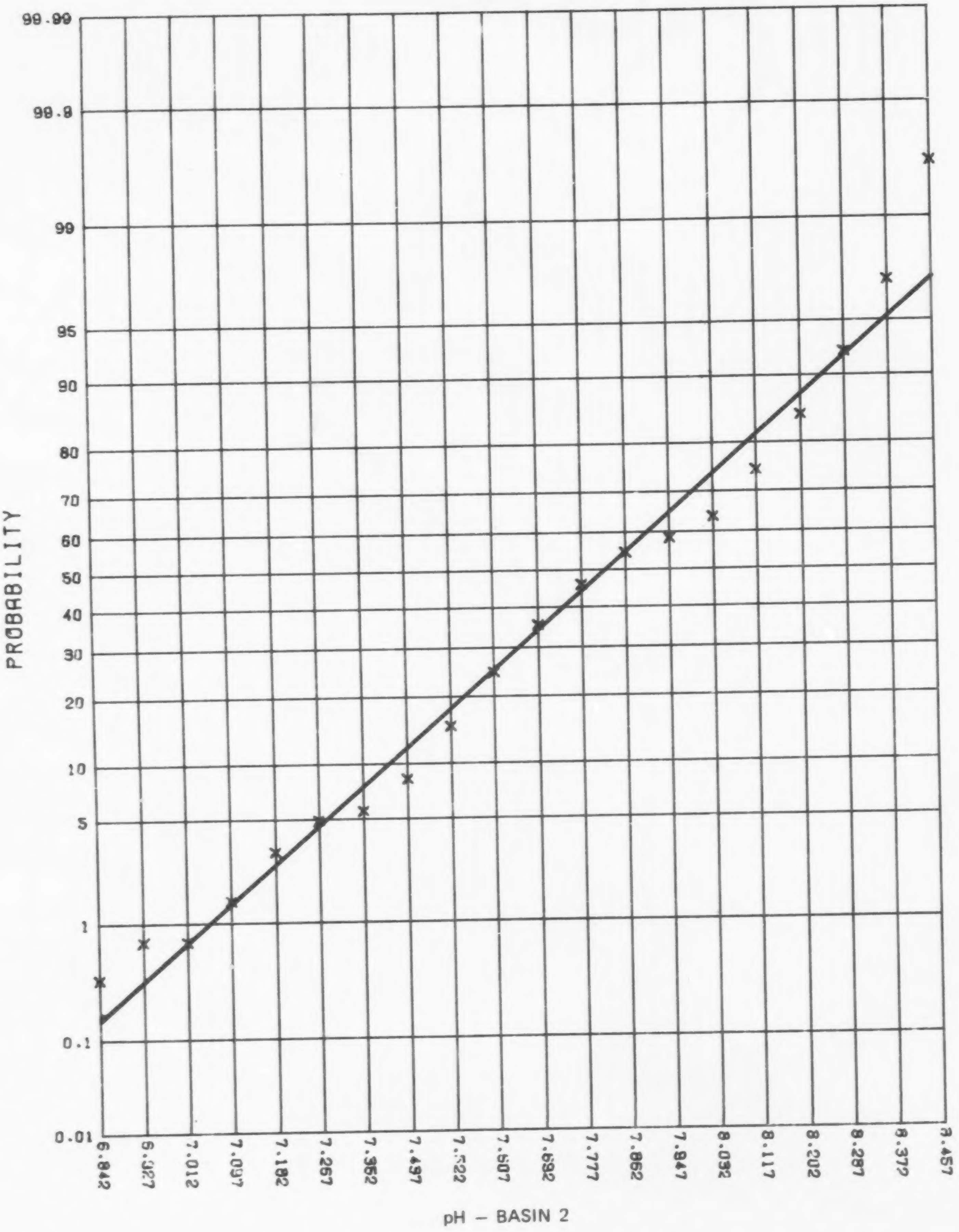


FIGURE 14

PROBABILITY OF pH BASIN 2

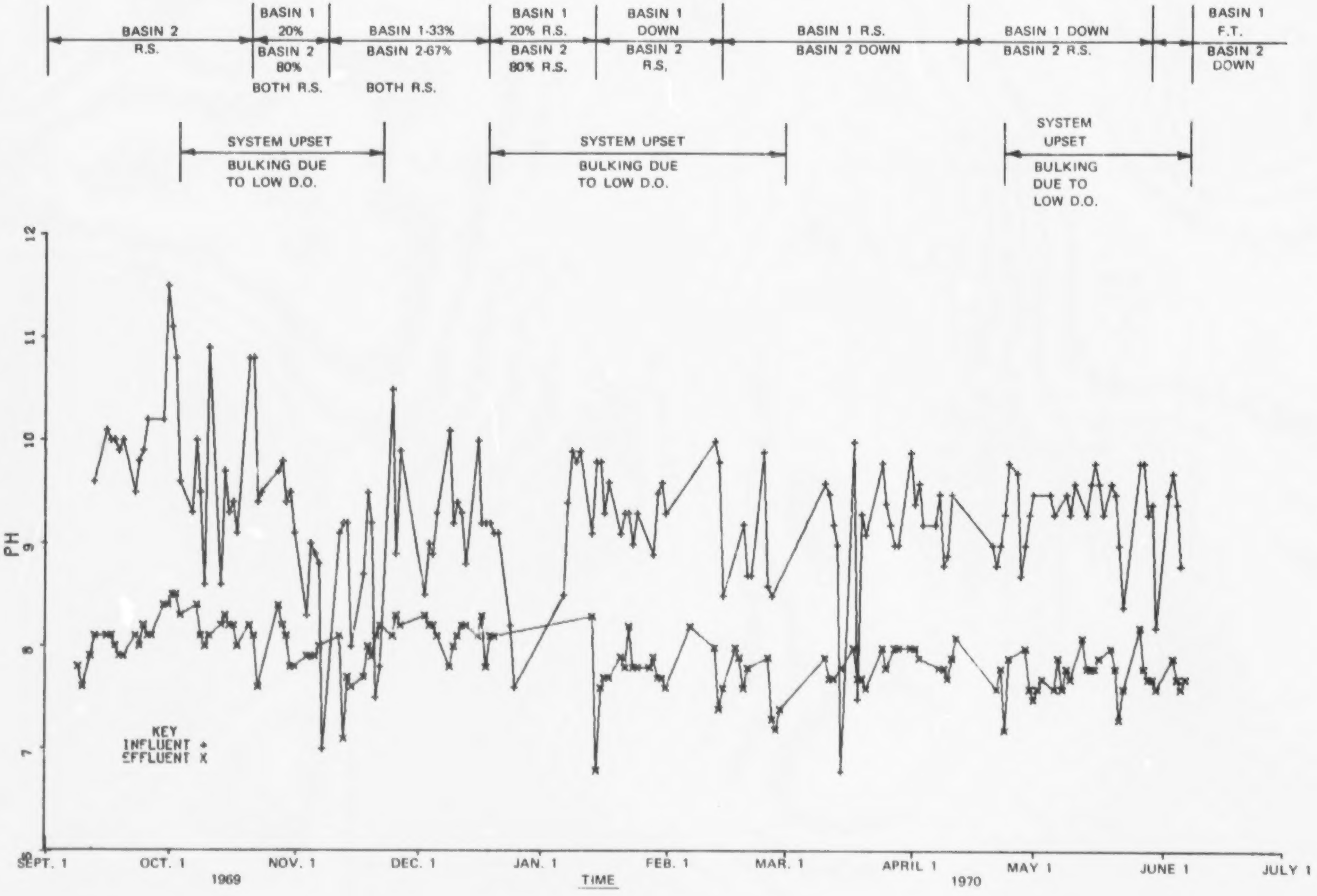


FIGURE 15

PLANT INFLUENT AND EFFLUENT PH
(ALL DATA)

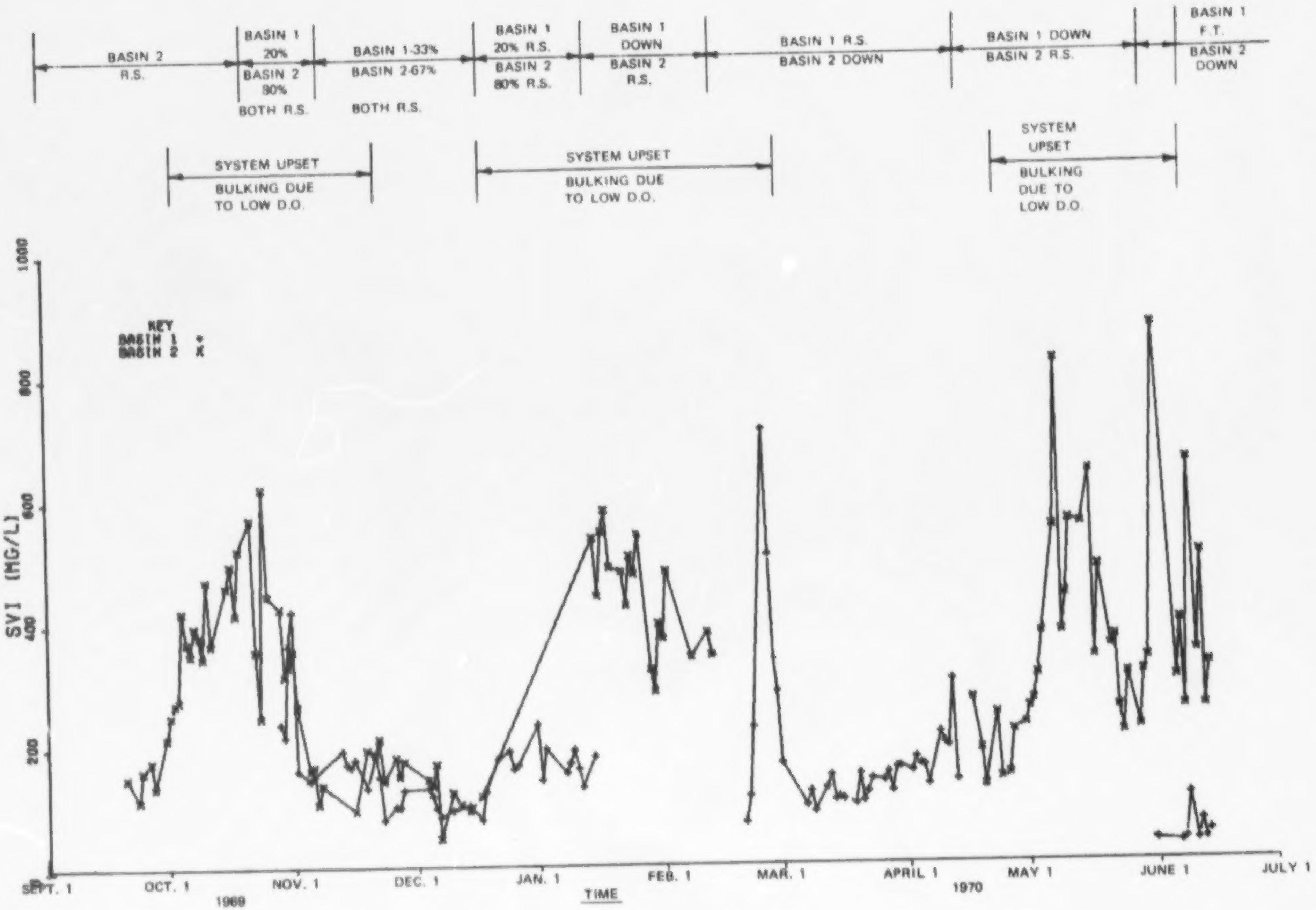


FIGURE 16

SVI VS TIME
(ALL DATA)

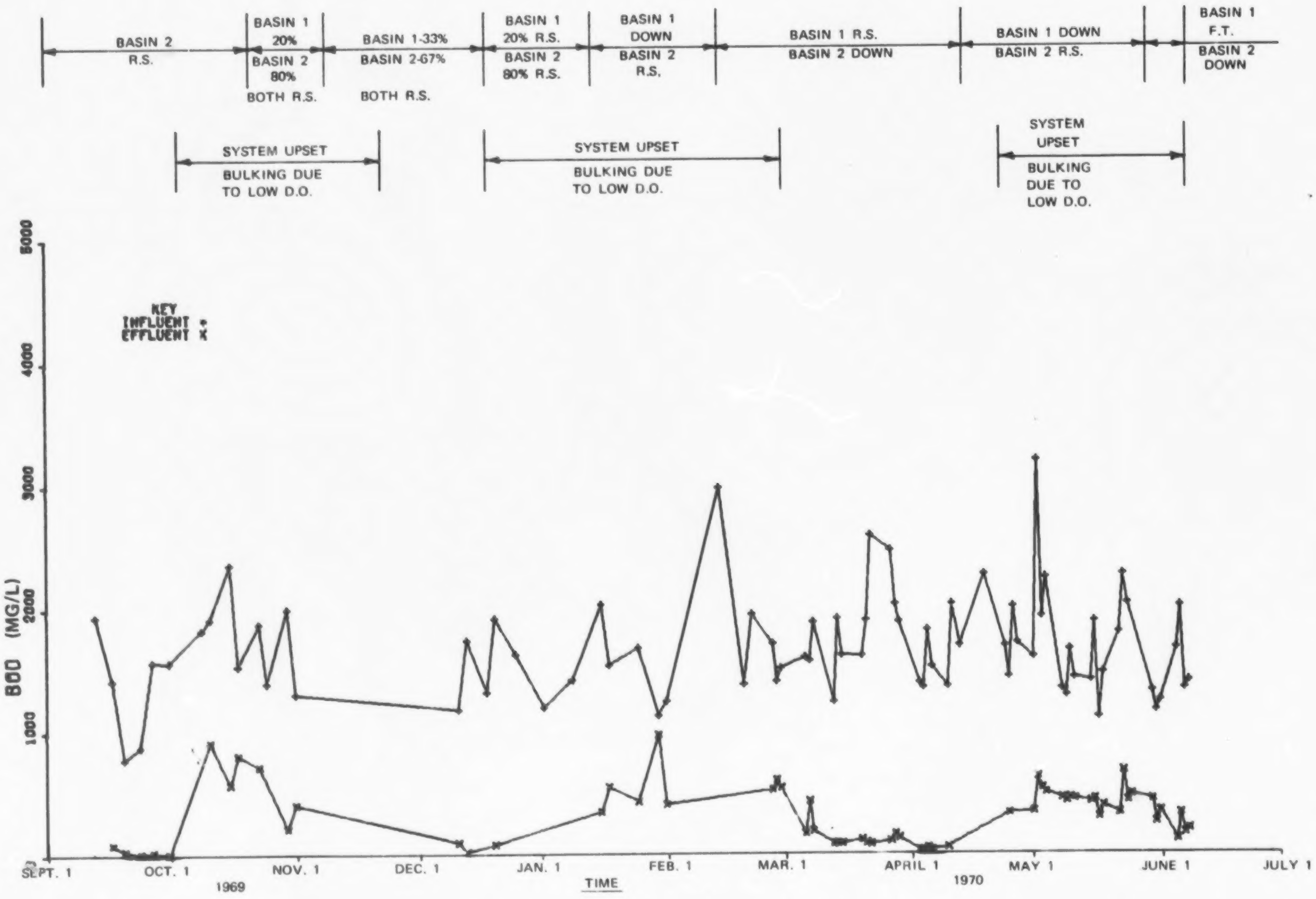


FIGURE 17

INFLUENT AND EFFLUENT BOD
(ALL DATA)

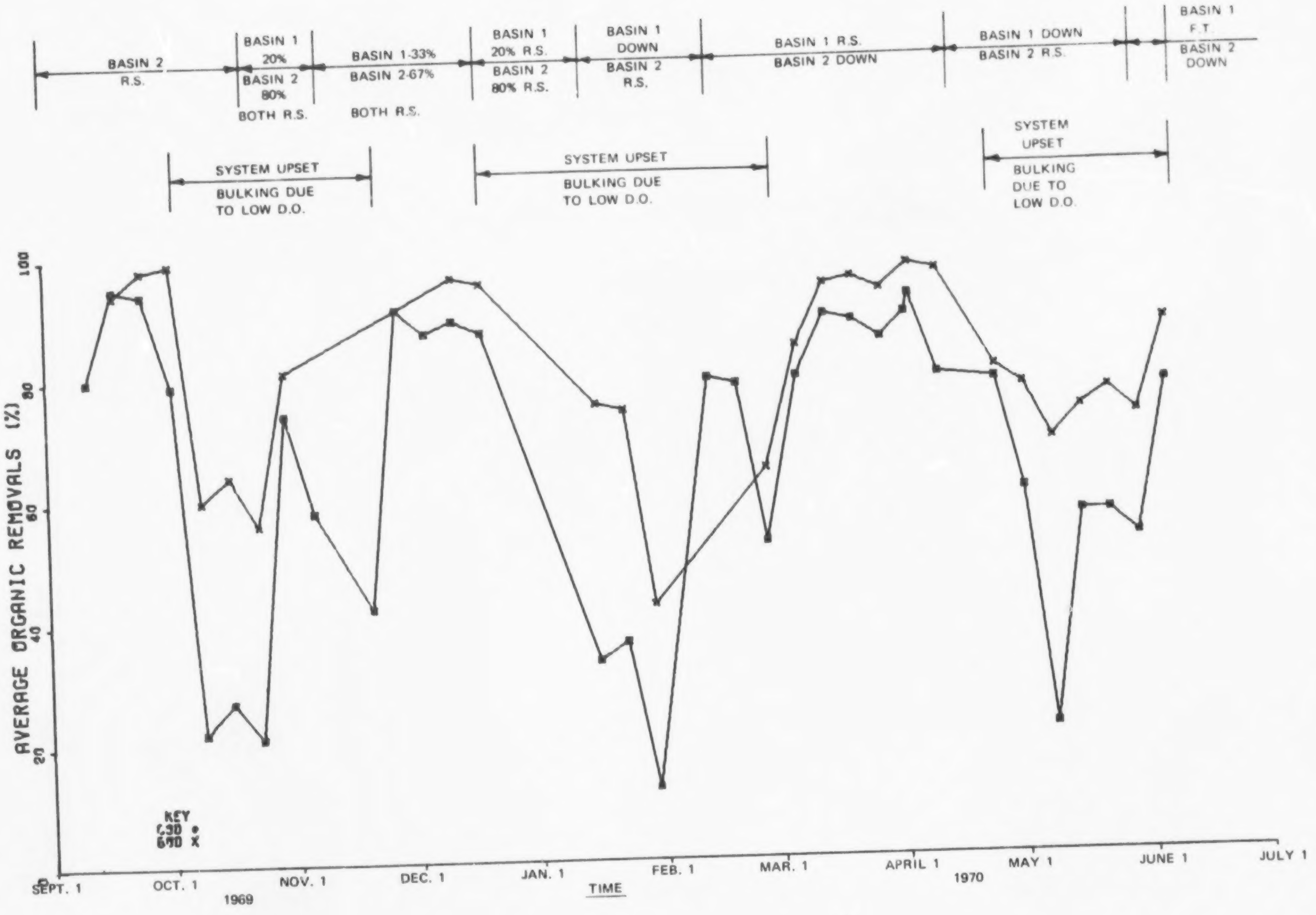


FIGURE 18

AVERAGE ORGANIC REMOVALS VS TIME
(ALL DATA)

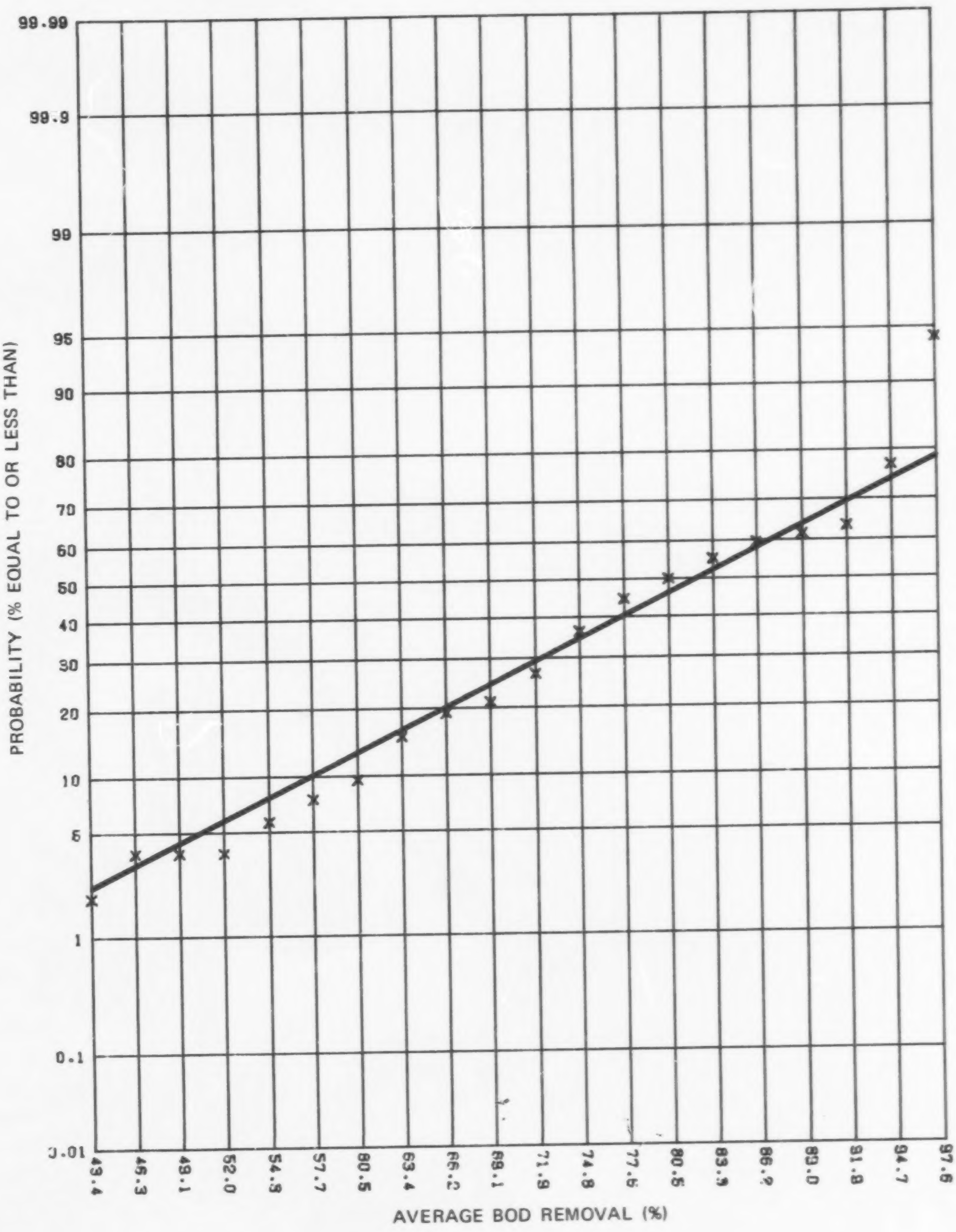


FIGURE 19

PROBABILITY OF AVERAGE BOD REMOVAL

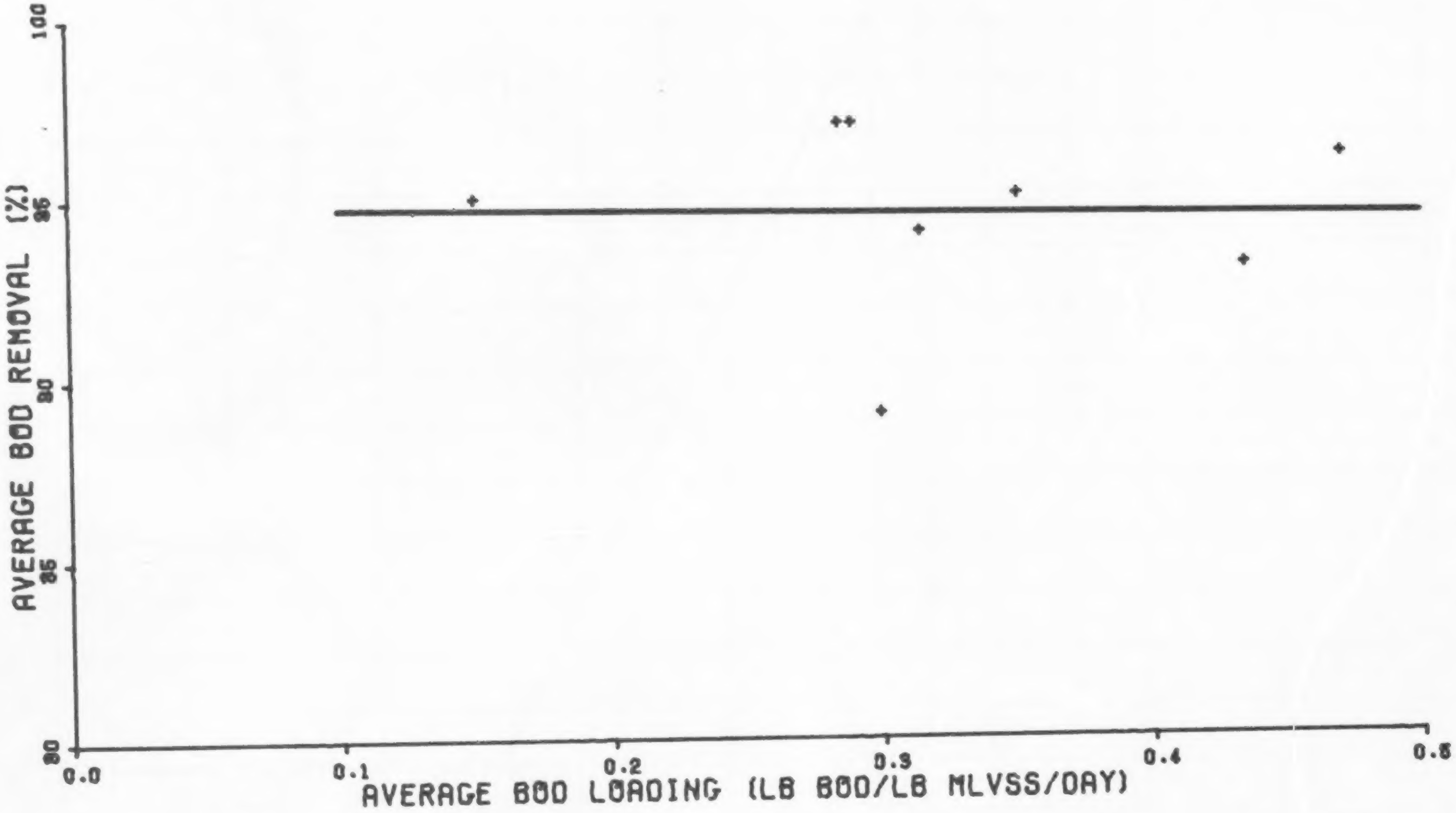


FIGURE 20

AVERAGE BOD REMOVAL VS. AVERAGE BOD LOADINGS
SELECTED DATA

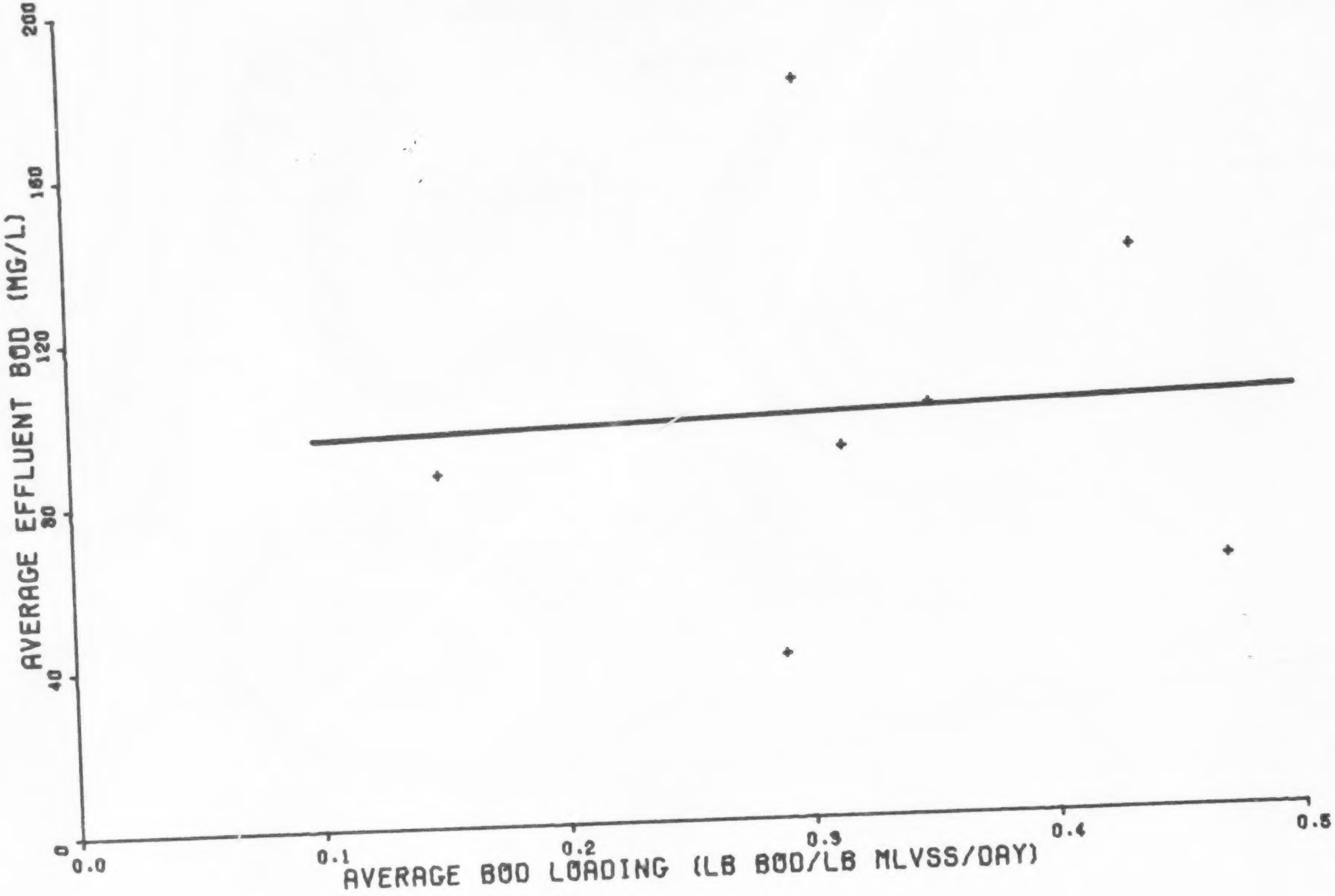


FIGURE 21

AVERAGE EFFLUENT BOD VS AVERAGE BOD LOADING
SELECTED DATA

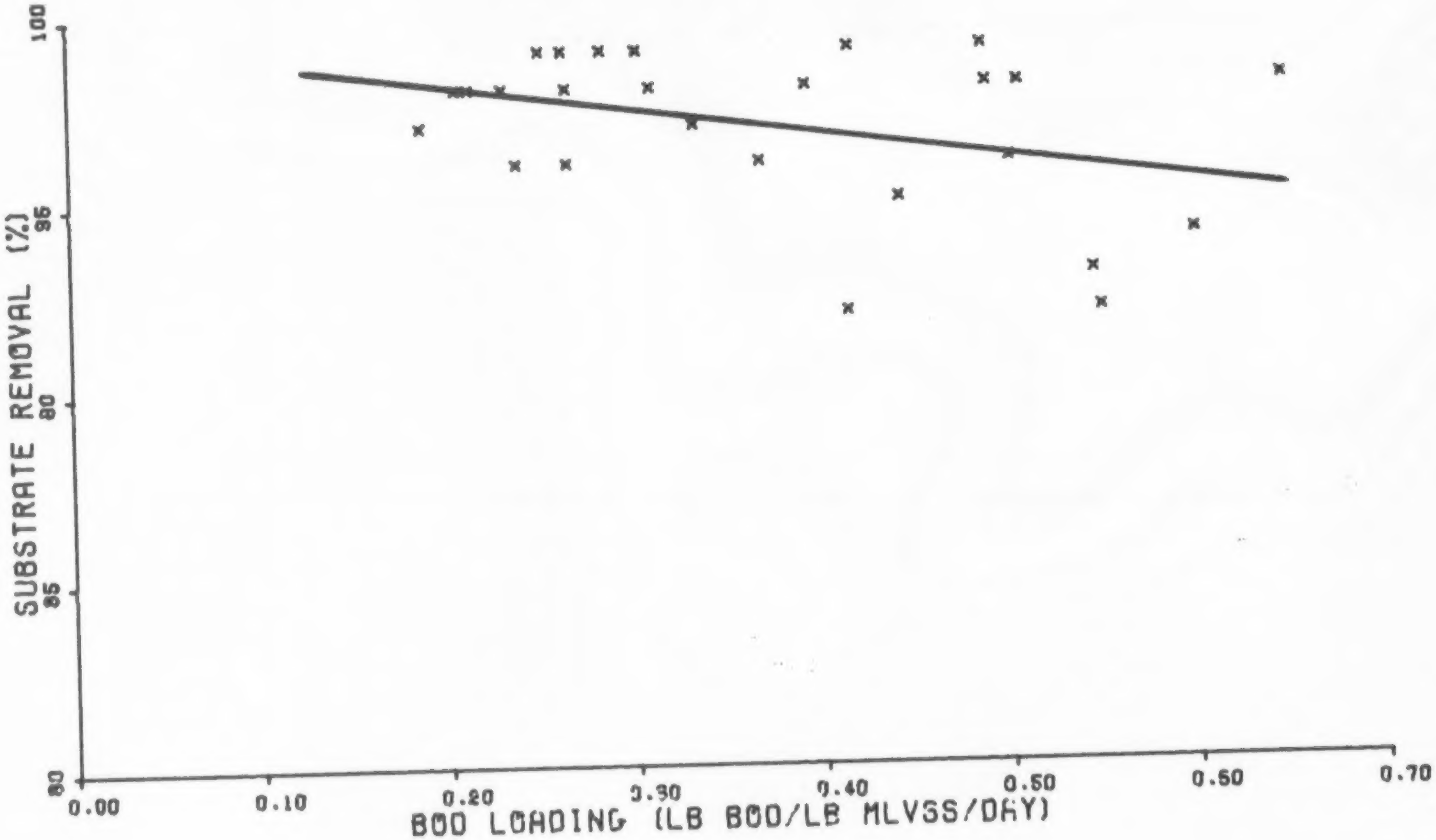


FIGURE 22

SUBSTRATE REMOVAL VS. BOD LOADING
ALL DATA

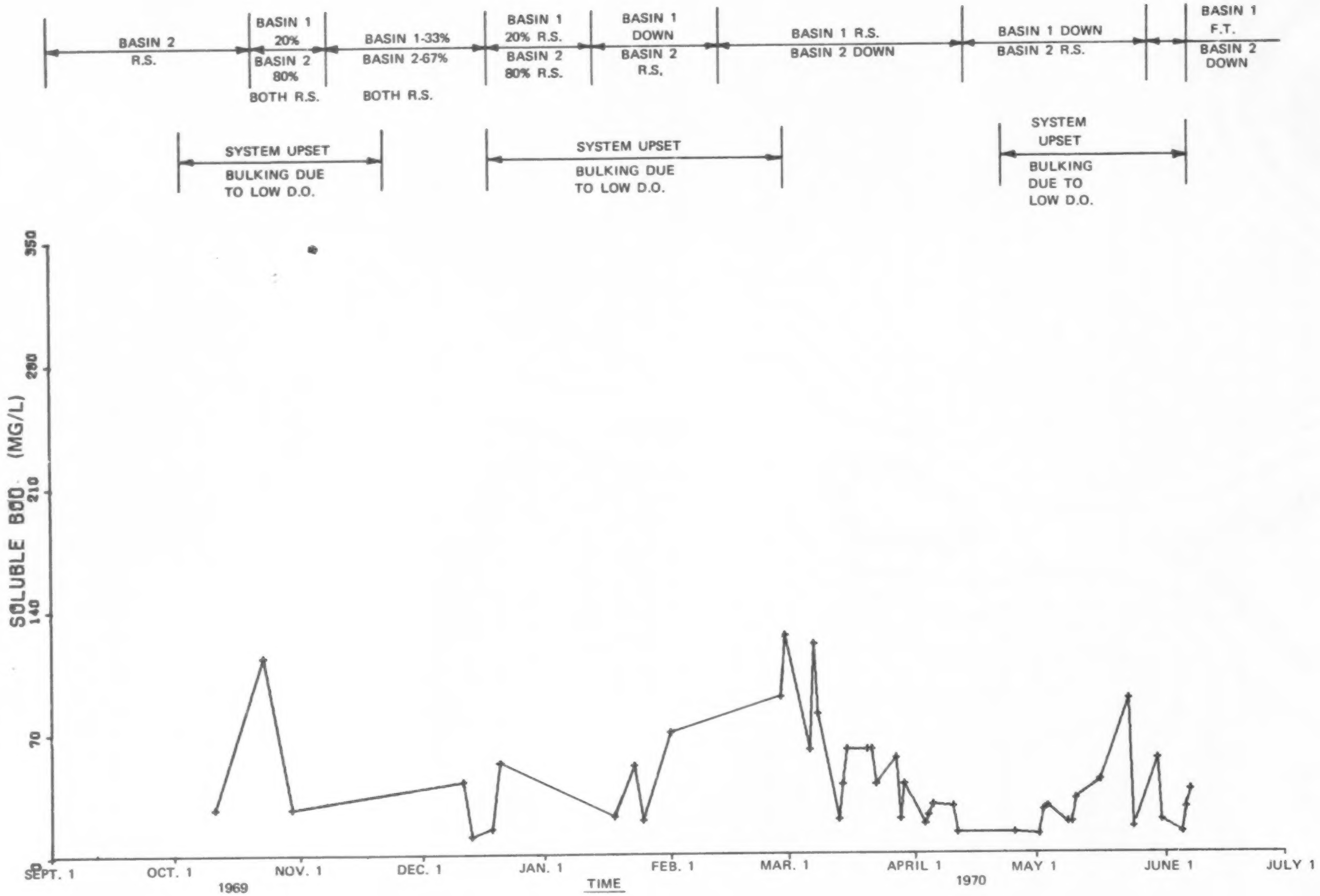


FIGURE 23

EFFLUENT SOLUBLE BOD
(ALL DATA)

Figure 24 shows the effect of BOD loading as lb BOD/1,000 cu ft/day on BOD removal. As the BOD loading increased, the BOD removal appeared to decrease slightly. MLVSS concentrations are not considered in this relationship.

Increased coliform bacteria reduction was achieved through the activated sludge system with increased basin liquor temperature (Figure 25). Results show that the system is capable of significant coliform count reduction. Effluent coliform concentrations averaged 3.9×10^7 per ml.

Figures 26 and 27 are related to secondary clarifier operation. Increased MLSS levels, with corresponding higher solids loading to the secondary clarifier, normally resulted in increased effluent suspended solids levels. Both figures have second-order curves.

Figure 28 shows that better secondary clarification would have reduced the effluent BOD. During periods of effective operation, SVI variations between 100 and 200 did not affect the effluent suspended solids (Figure 29).

Total phosphate and total nitrogen removal variations with time are shown on Figures 30 and 31. Decreased removal efficiencies coincide with periods of sludge bulking and loss of bacterial cells in the secondary clarifier effluent.

Figures 32 and 33 show BOD removal and substrate removal (soluable BOD) versus BOD loadings while Basin 1 was operated as a flow-through aeration basin without secondary clarification. The difference in the two removal curves on each figure represents the BOD of the suspended solids in the basin effluent.

Limited chlorine breakpoint testing of the plant effluent provided a breakpoint range from 14 to 18 mg/l and an average of 15 mg/l.

The average effluent characteristics during effective activated sludge treatment are listed below:

pH = 8.0
Temperature = 16.4 degrees C.
Suspended Solids = 160 mg/l
COD = 380 mg/l
BOD = 85 mg/l
Soluble BOD = 40 mg/l
Chlorine Breakpoint = 15 mg/l

Additional effluent relationships are located in Appendix C.

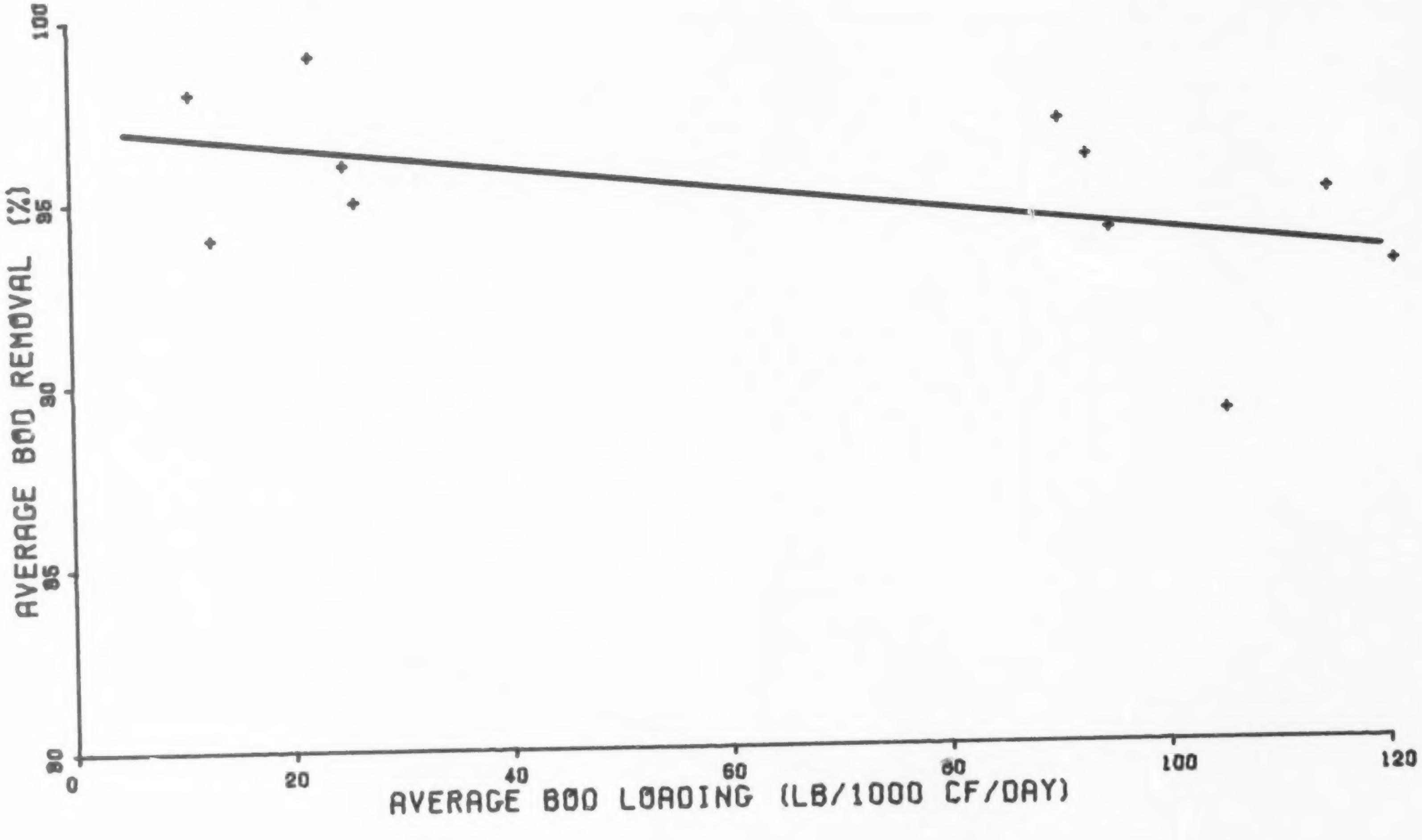


FIGURE 24

AVERAGE BOD REMOVAL VS AVERAGE BOD LOADING
SELECTED DATA

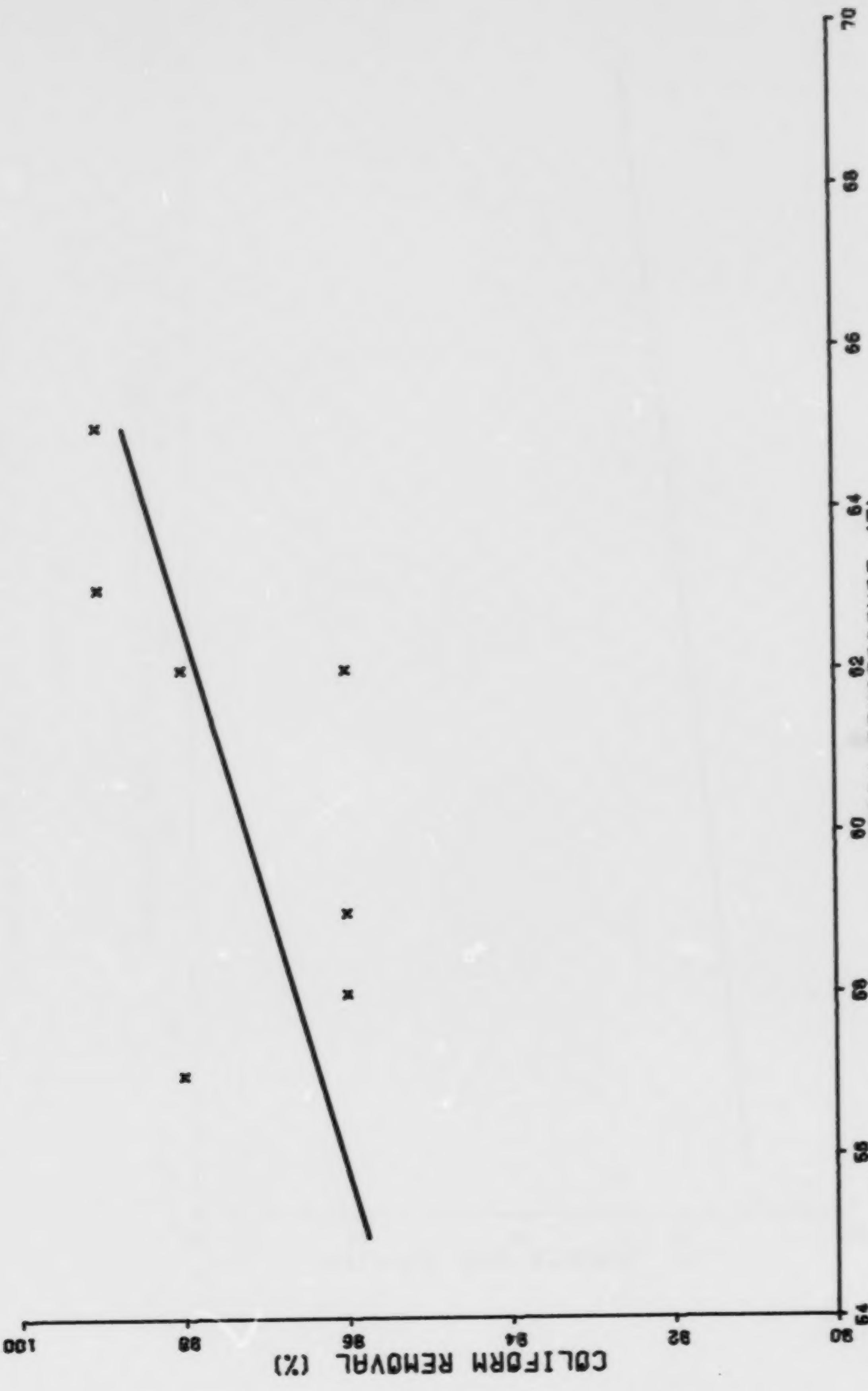


FIGURE 25

BASIN TEMPERATURE VS COLIFORM REMOVAL
(ALL DATA)

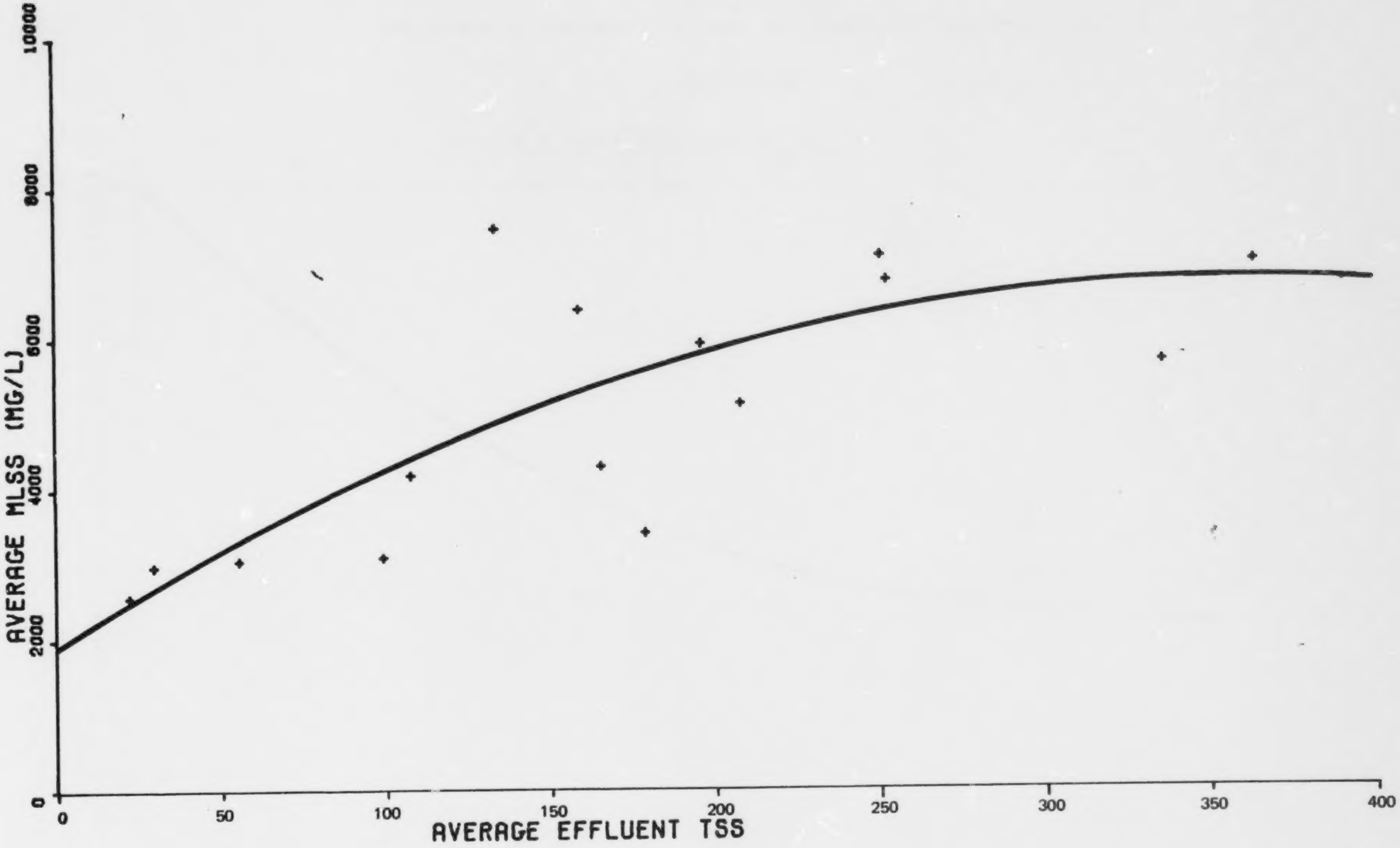


FIGURE 26

AVERAGE MLSS VS AVERAGE EFFLUENT TSS
SELECTED DATA

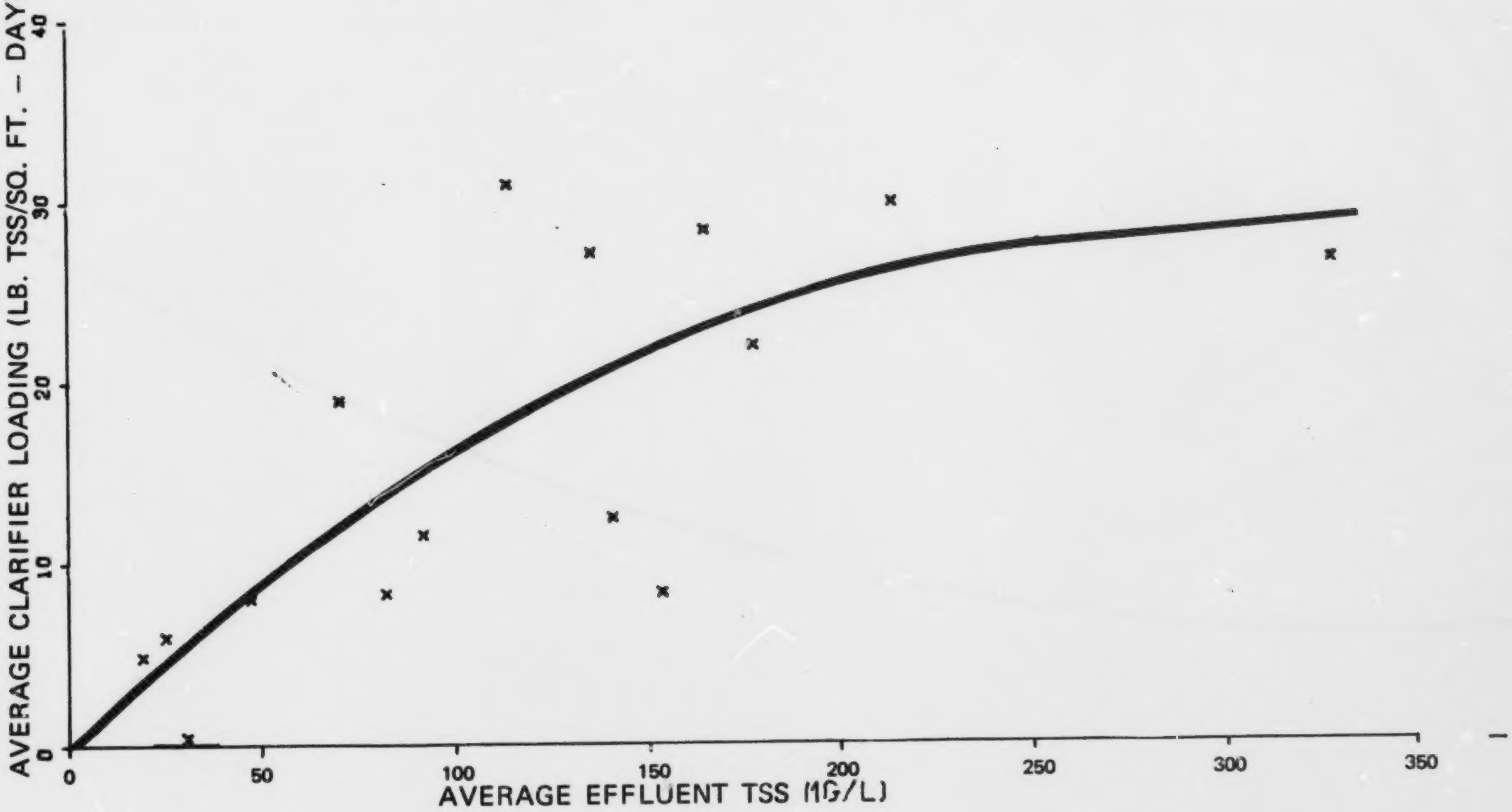


FIGURE 27

AVERAGE CLARIFIER LOADING VS. AVERAGE EFFLUENT TSS
(SELECTED DATA)

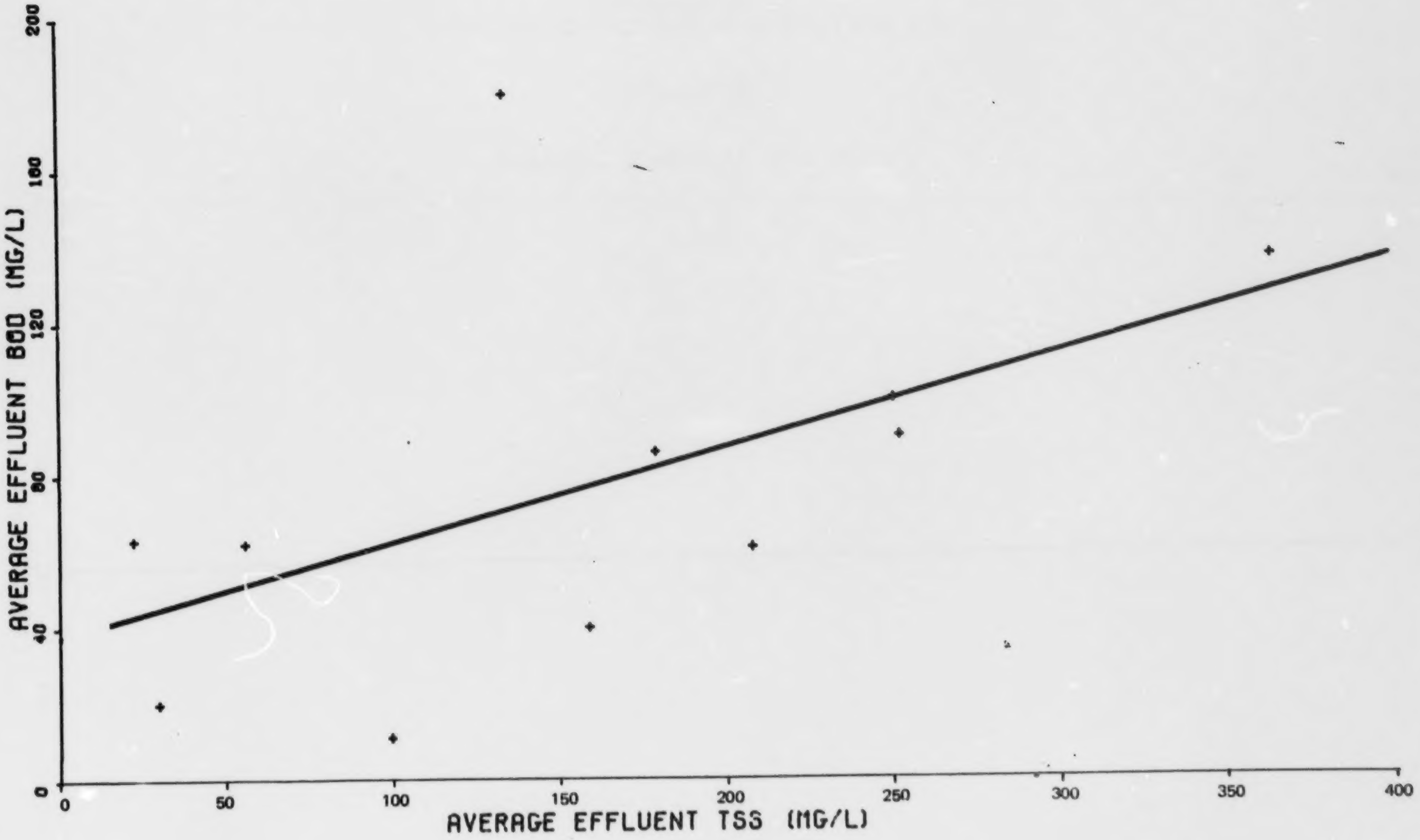


FIGURE 28

AVERAGE EFFLUENT BOD VS. AVERAGE EFFLUENT TSS
(SELECTED DATA)

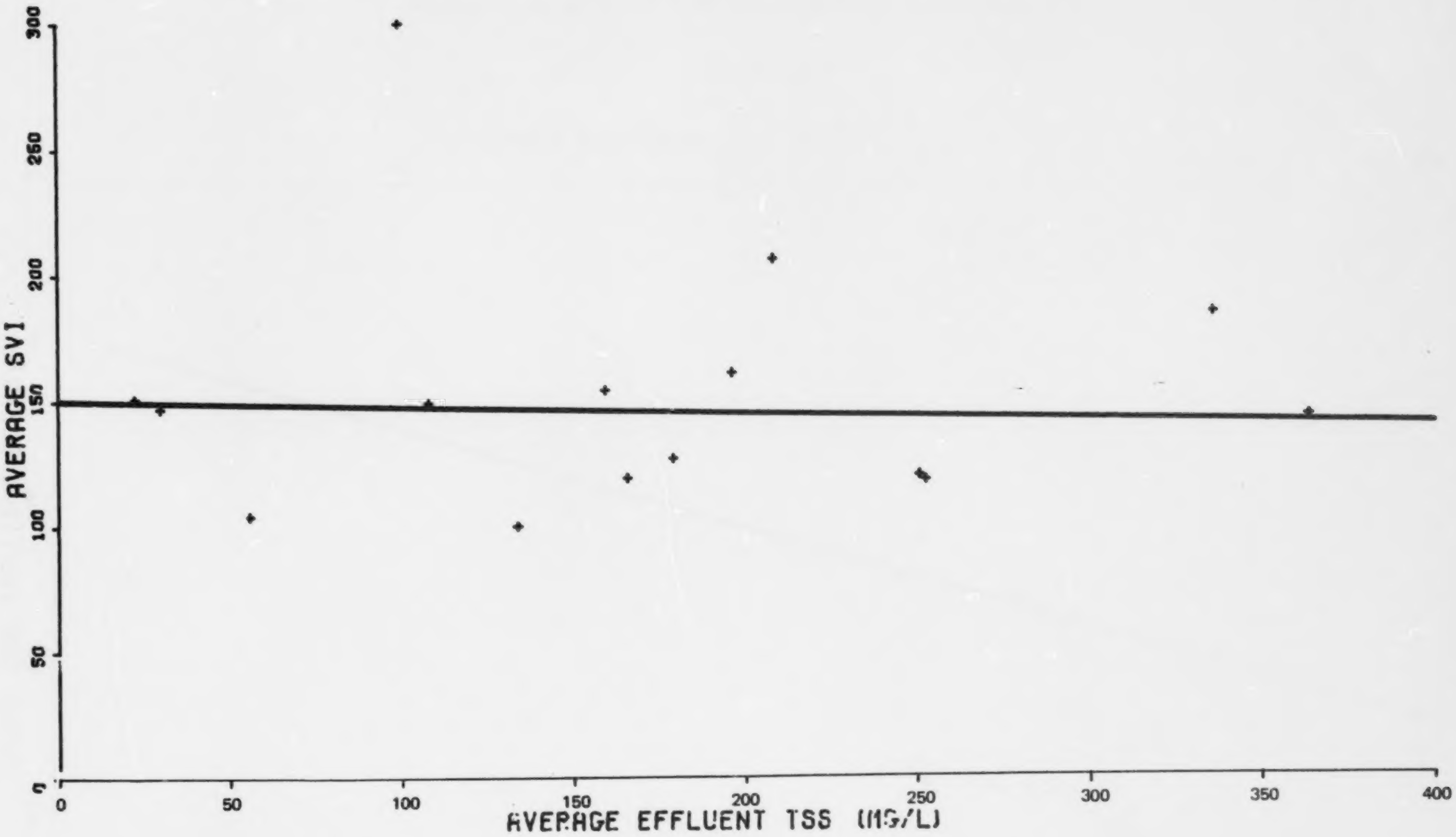


FIGURE 29

AVERAGE SVI VS. AVERAGE EFFLUENT TSS
(SELECTED DATA)

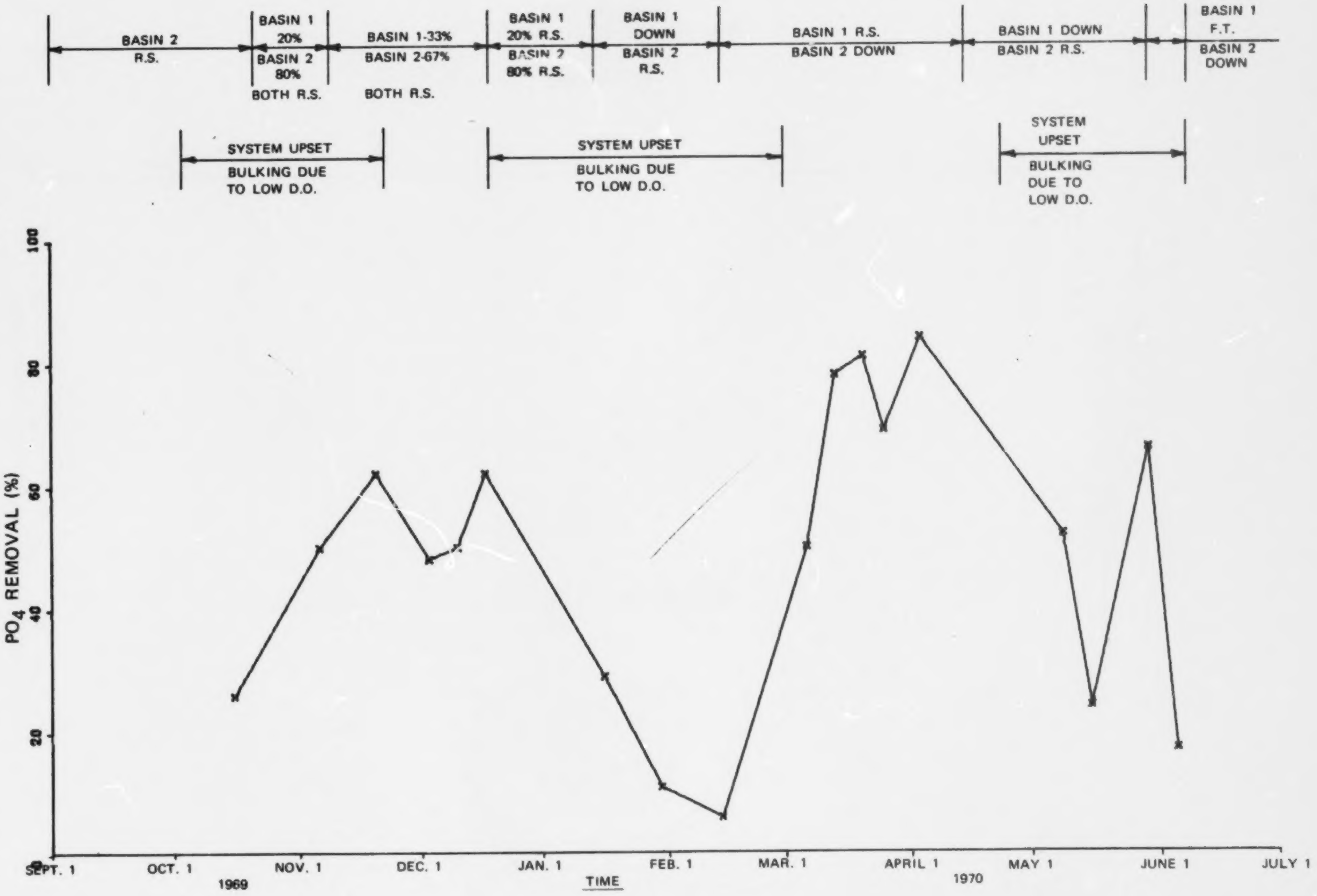


FIGURE 30

TOTAL PHOSPHATE REMOVAL VS. TIME
(ALL DATA)

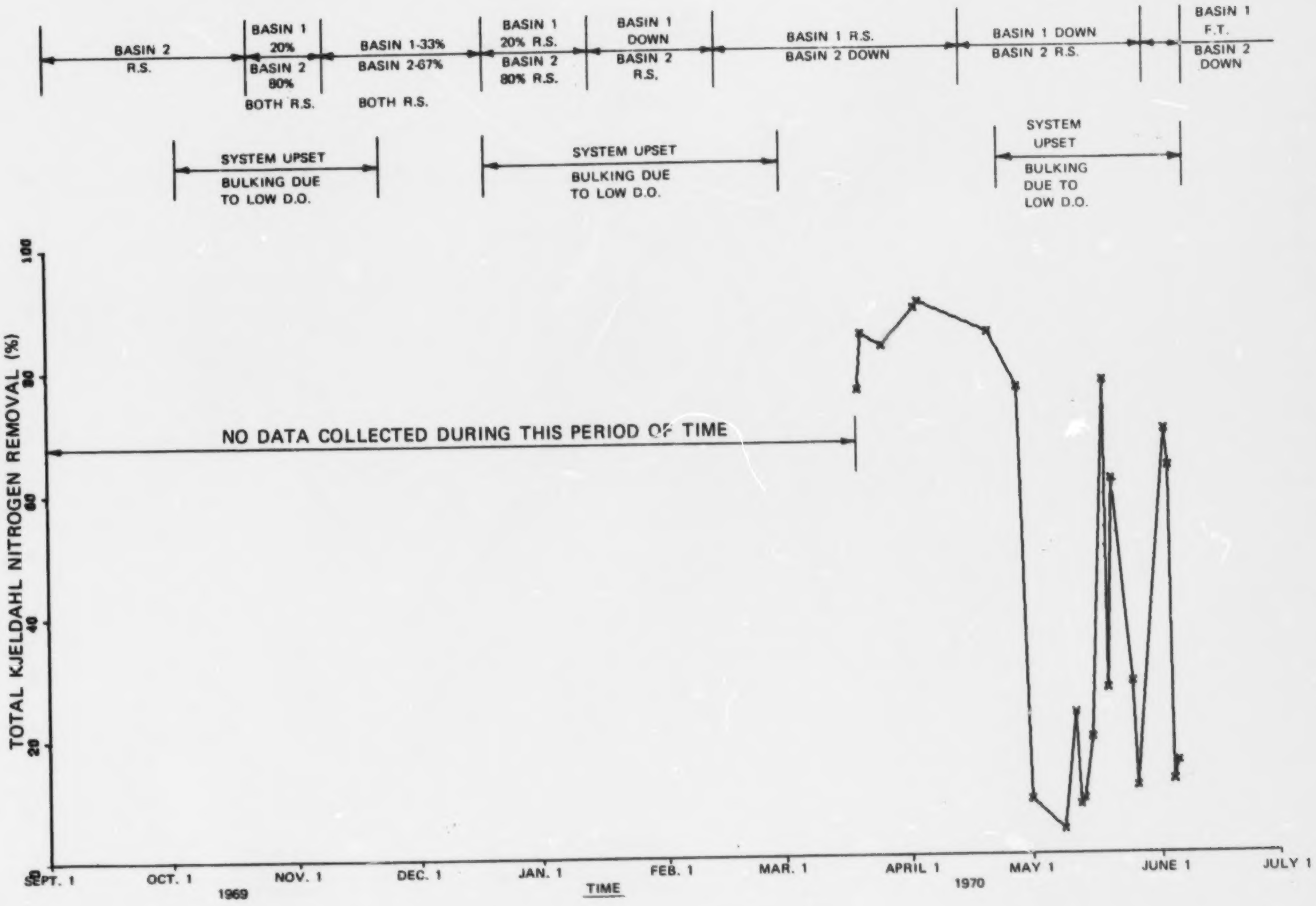


FIGURE 31

NITROGEN REMOVAL VS. TIME
(ALL DATA)

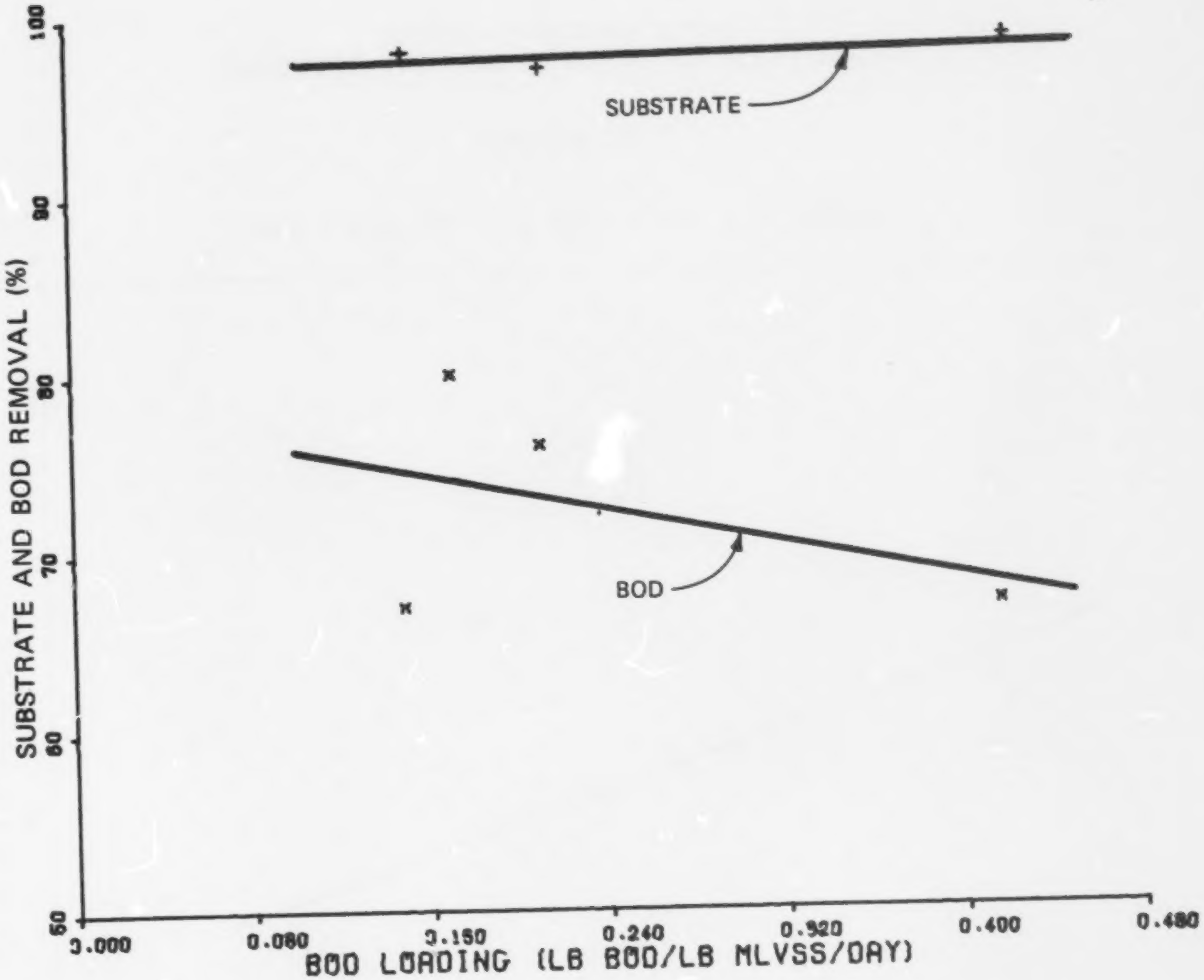


FIGURE 32

SUBSTRATE AND BOD REMOVAL VS. BOD LOADING
FLOW–THROUGH DATA

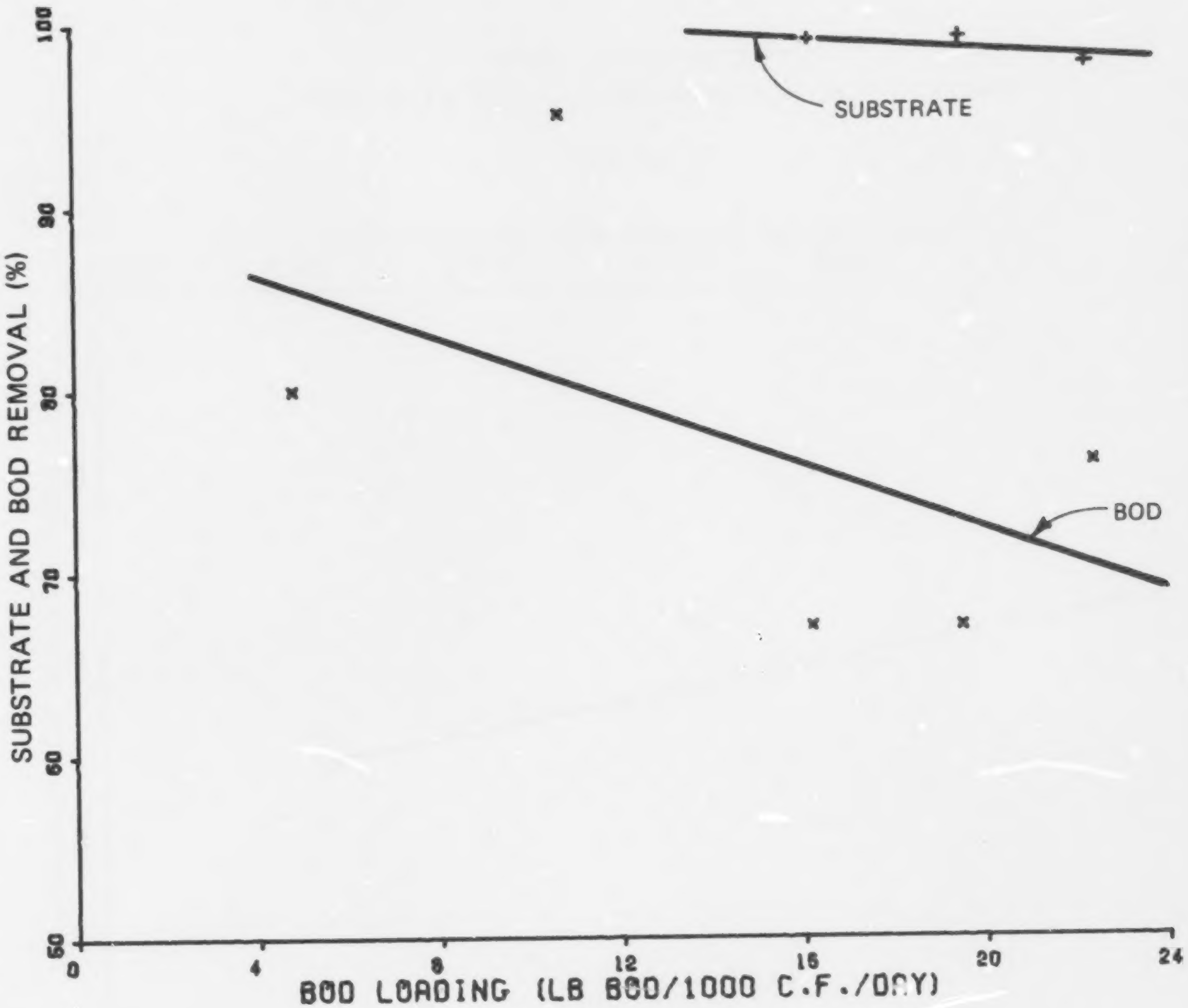


FIGURE 33

SUBSTRATE AND BOD REMOVAL VS. BOD LOADING
(FLOW – THROUGH DATA)

VELOCITY PROFILES–Velocity measurements were made in the aeration basins with three different aerator arrangements. An example of velocity profiles obtained is shown in plan view on Figure 34 and in section on Figure 35. Additional velocity profile plots are located in Appendix G.

Measurements were made from a raft with a propeller type current meter and counter made by A. Ott. The velocity profile is meaningful for evaluating possible minimum or maximum velocities in the given areas of the basins during operation. Each of the aerators has a nameplate horsepower of 50 and an impeller pumping rate of 23,500 gallons per minute at a power draw of 67 amperes. The aerator power use during the testing is provided on the figures. Some minor scour was noted in the high velocity and turbulence areas at the ends and sides of Aeration Basin 1 after about two months of operation without a plastic liner. The scour was 6 to 8 inches deep and was located primarily in the wave action zone.

DISSOLVED OXYGEN PROFILES–Dissolved oxygen measurements were taken in the aeration basins at various depths with four different aerator location configurations. The dissolved oxygen readings were obtained with a YSI field probe and meter from a raft. Figures 36 through 39 show dissolved oxygen profiles for the basins with power loadings from about 90 to 245 hp per million gallons of aeration basin mixed liquor. Dissolved oxygen profiles, at 2-foot and 6-foot depths of Basin 1 with 9 aerators, are shown on Figures 38 and 39, respectively. A section profile taken through these plan profiles is included as Figure 40. Other dissolved oxygen profiles are located in Appendix G. The power use for each aerator is given on the figures.

The dissolved oxygen distribution shown on Figures 38 through 40 was fairly uniform. Having one of nine aerators out of operation does not appear to have affected the dissolved oxygen distribution in the basin at the time of the measurements. If the aerator out of operation had been at the end of the basin, the effect might have been more noticeable.

OXYGEN UPTAKE RATES–Oxygen uptake studies were conducted on grab samples of aeration basin mixed liquor. The oxygen uptake tests were conducted by placing the sample in a BOD bottle, mixing with a magnetic stirrer, and using a YSI BOD bottle probe. Dissolved oxygen values obtained during the first 60 seconds and below 1.0 mg/l were discounted in determing the slope of the oxygen uptake plot. Plots of dissolved oxygen depletion with time are included in Appendix G. The oxygen uptake rates varied from 0.06 to 0.26 mg O_2 per day per mg MLVSS with corresponding temperatures of 11.3 and 15.5 degrees C. These uptake rates are described in more detail in Section 11.

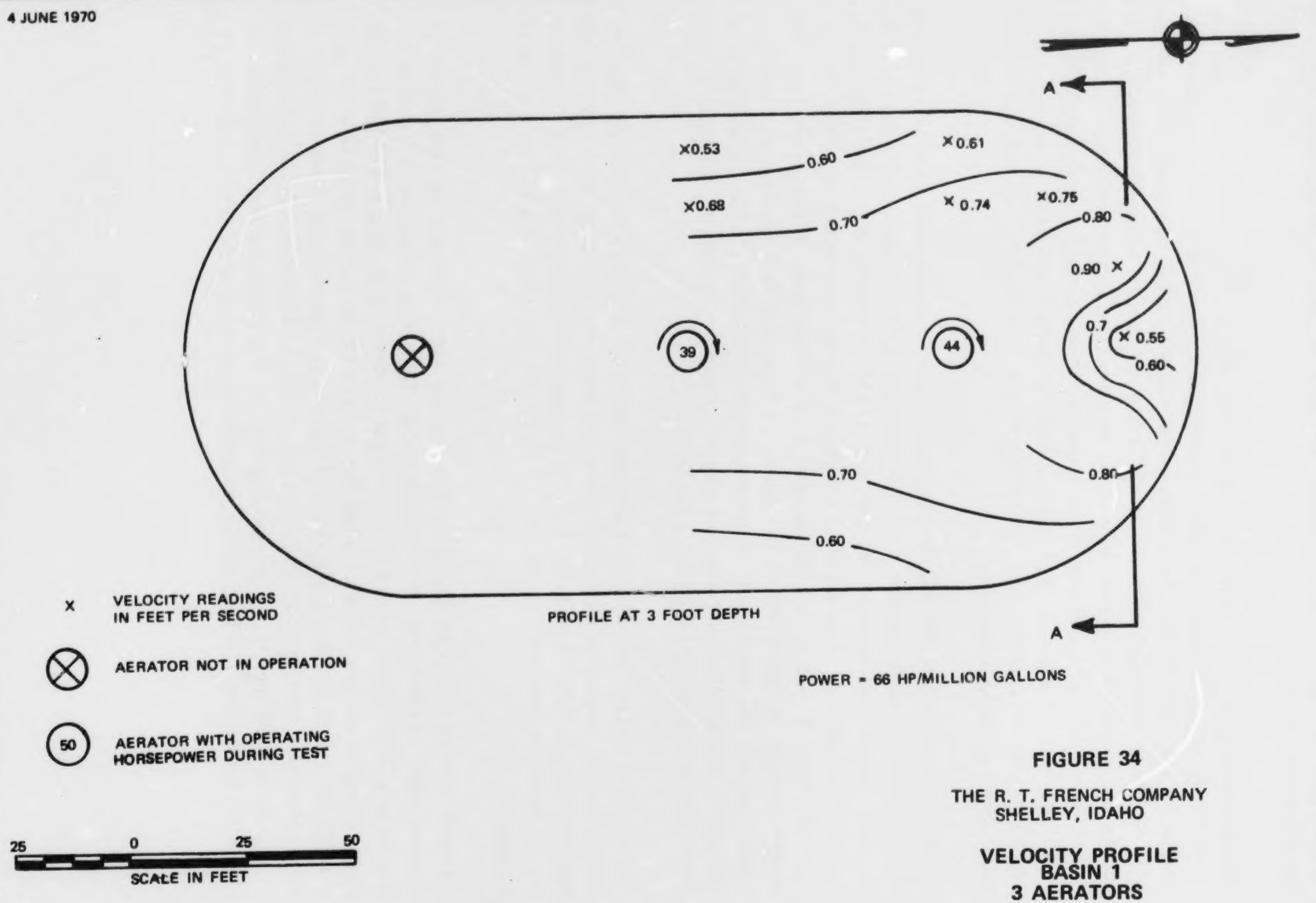

4 JUNE 1970
A
A
×0.53
0.60
×0.61
×0.68
0.70
× 0.74
×0.75
0.80
0.90 ×
0.7
× 0.55
0.60
39
44
0.70
0.80
0.60
PROFILE AT 3 FOOT DEPTH
×
VELOCITY READINGS IN FEET PER SECOND
AERATOR NOT IN OPERATION
50
AERATOR WITH OPERATING HORSEPOWER DURING TEST
25
0
25
50
SCALE IN FEET
POWER = 66 HP/MILLION GALLONS

FIGURE 34

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

VELOCITY PROFILE
BASIN 1
3 AERATORS

4 JUNE 1970

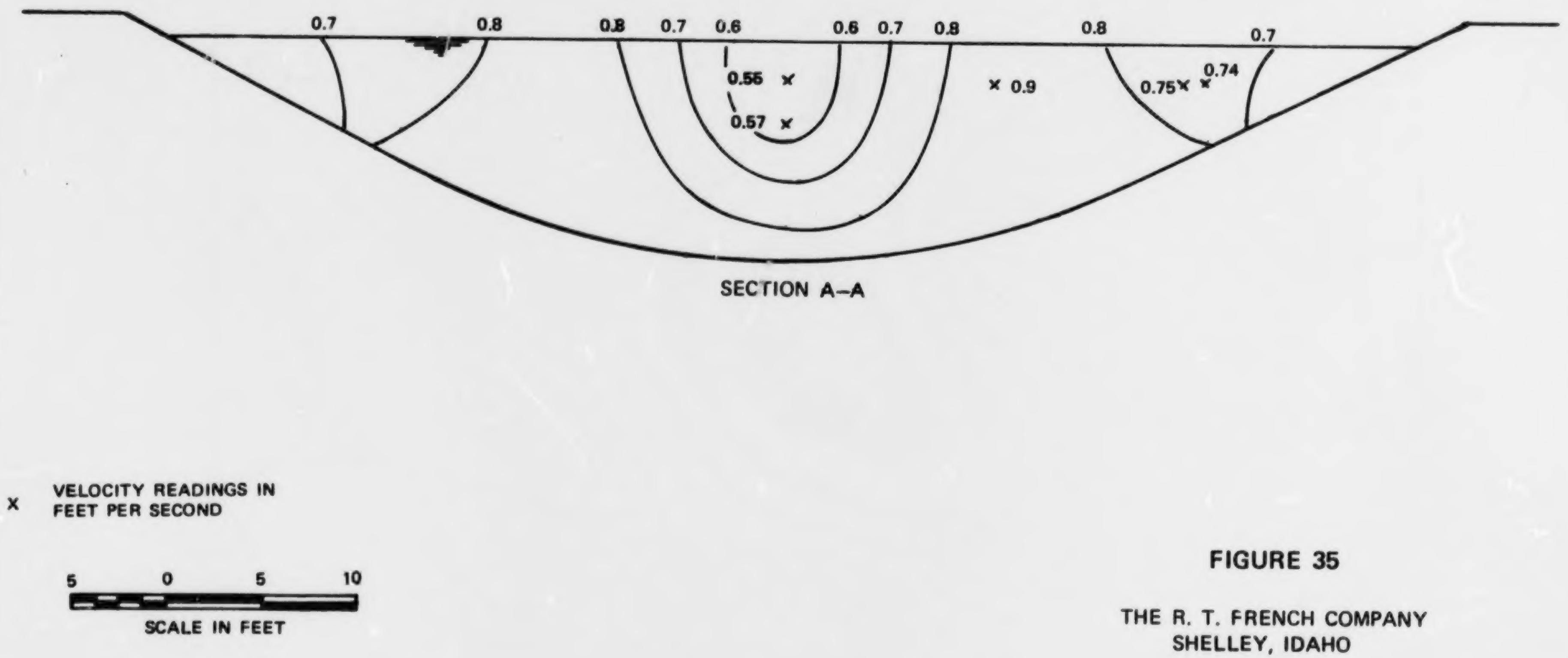

0.7
0.8
0.8
0.7
0.6
0.6
0.7
0.8
0.8
0.7
0.55
0.57
0.9
0.75
0.74
SECTION A–A
x VELOCITY READINGS IN FEET PER SECOND
5
0
5
10
SCALE IN FEET

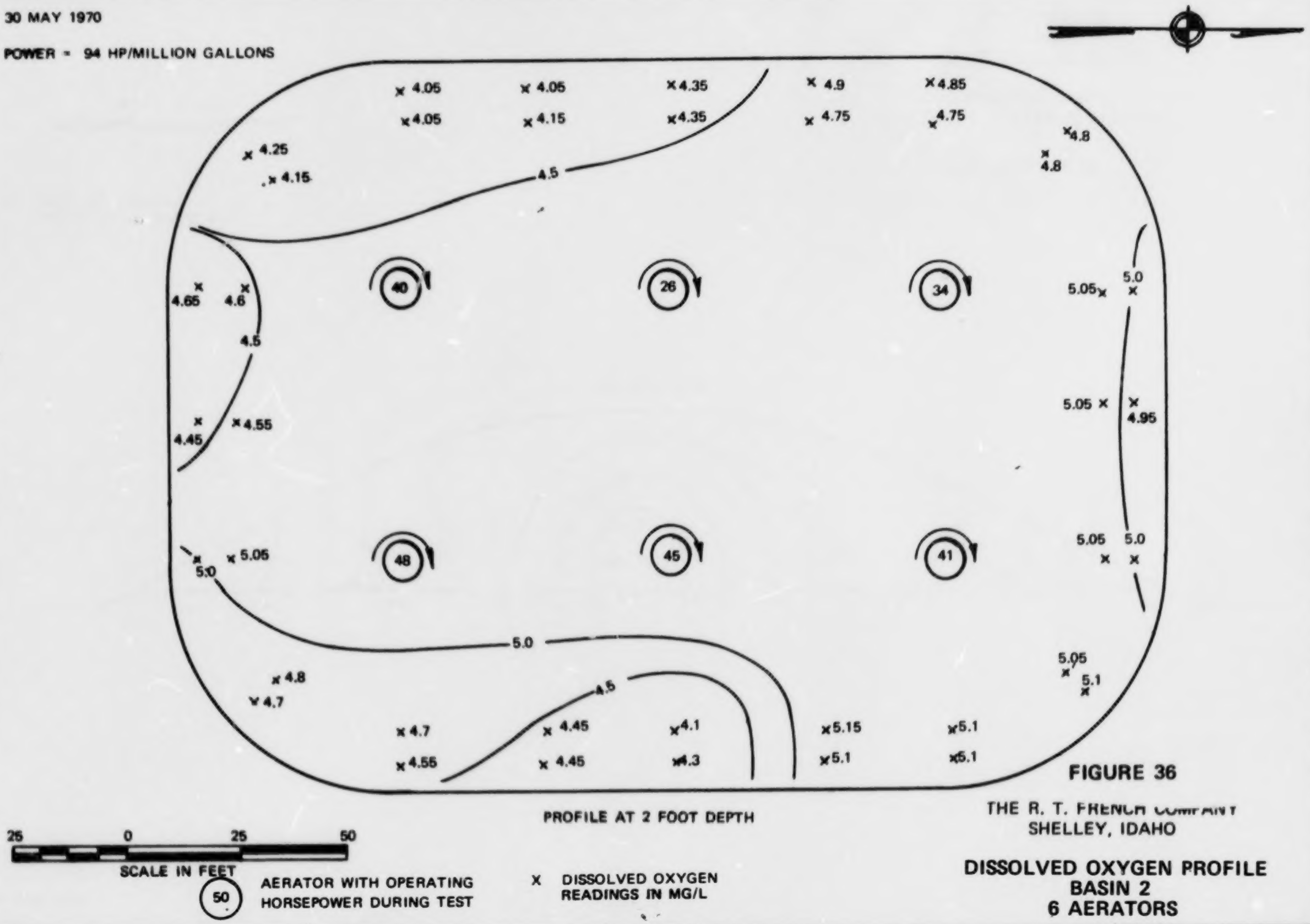
FIGURE 35

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

VELOCITY PROFILE
BASIN 1
3 AERATORS

30 MAY 1970

POWER = 94 HP/MILLION GALLONS


4.05
4.05
4.05
4.15
4.35
4.35
4.9
4.75
4.85
4.75
4.25
4.15
4.8
4.8
4.5
4.65
4.6
4.5
4.45
4.55
40
26
34
5.05
5.0
5.05
4.95
5.05
5.0
5.0
5.05
48
45
41
5.0
4.8
4.7
5.05
5.1
4.5
4.7
4.55
4.45
4.45
4.1
4.3
5.15
5.1
5.1
5.1
25
0
25
50
SCALE IN FEET
50
AERATOR WITH OPERATING HORSEPOWER DURING TEST
X DISSOLVED OXYGEN READINGS IN MG/L

PROFILE AT 2 FOOT DEPTH

FIGURE 36

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 2
6 AERATORS

30 MAY 1970

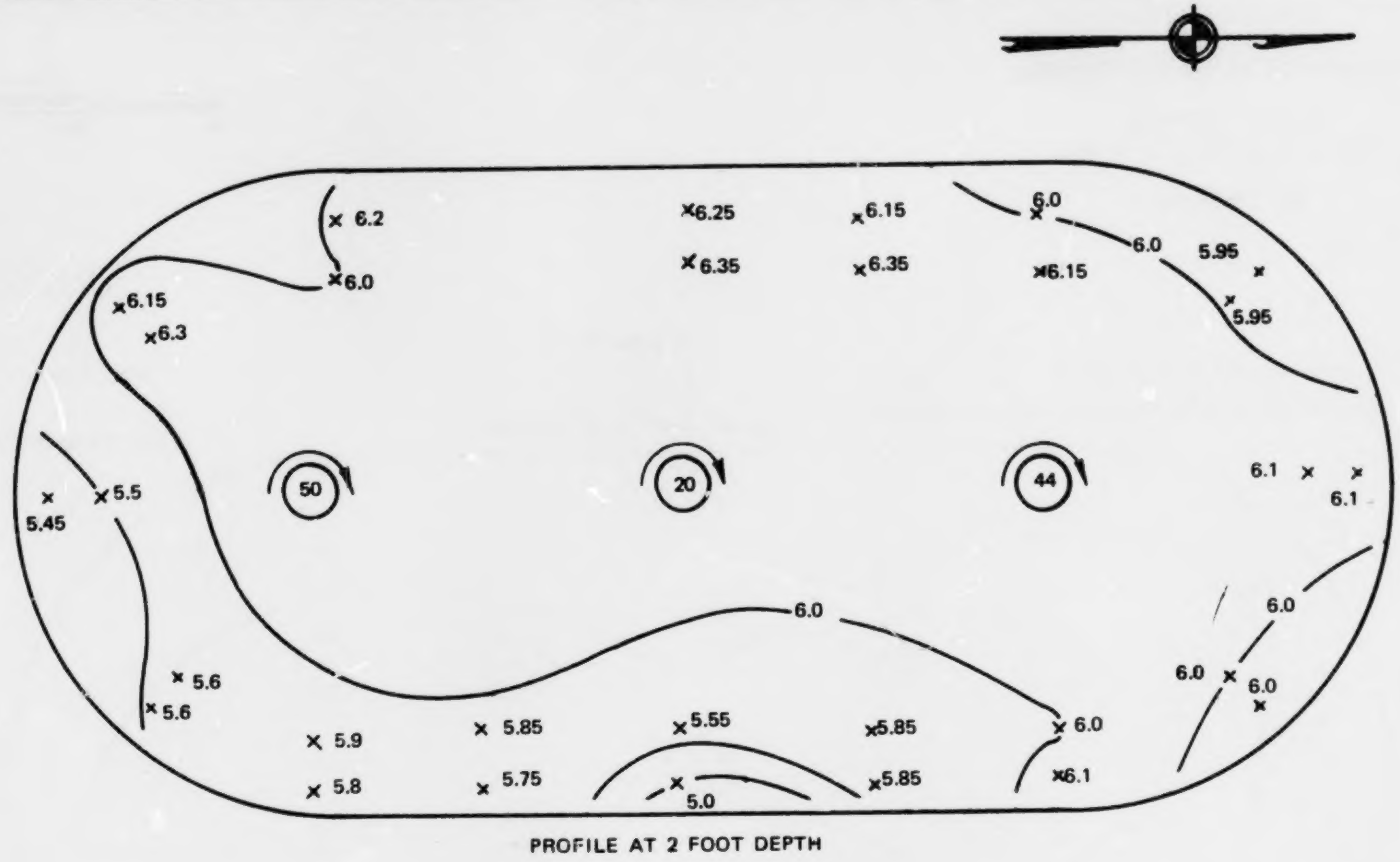

6.2
6.0
6.15
6.3
5.45
5.5
5.6
5.6
50
5.9
5.8
5.85
5.75
6.25
6.35
20
6.0
5.55
5.0
6.15
6.35
5.85
5.85
6.0
6.0
6.15
44
6.0
6.1
6.0
5.95
5.95
6.1
6.1
6.0
6.0
6.0
PROFILE AT 2 FOOT DEPTH
50
AERATOR WITH OPERATING HORSEPOWER DURING TEST
X
DISSOLVED OXYGEN READINGS IN MG/L
POWER = 91 HP/MILLION GALLONS
25
0
25
50
SCALE IN FEET

FIGURE 37

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 1
3 AERATORS

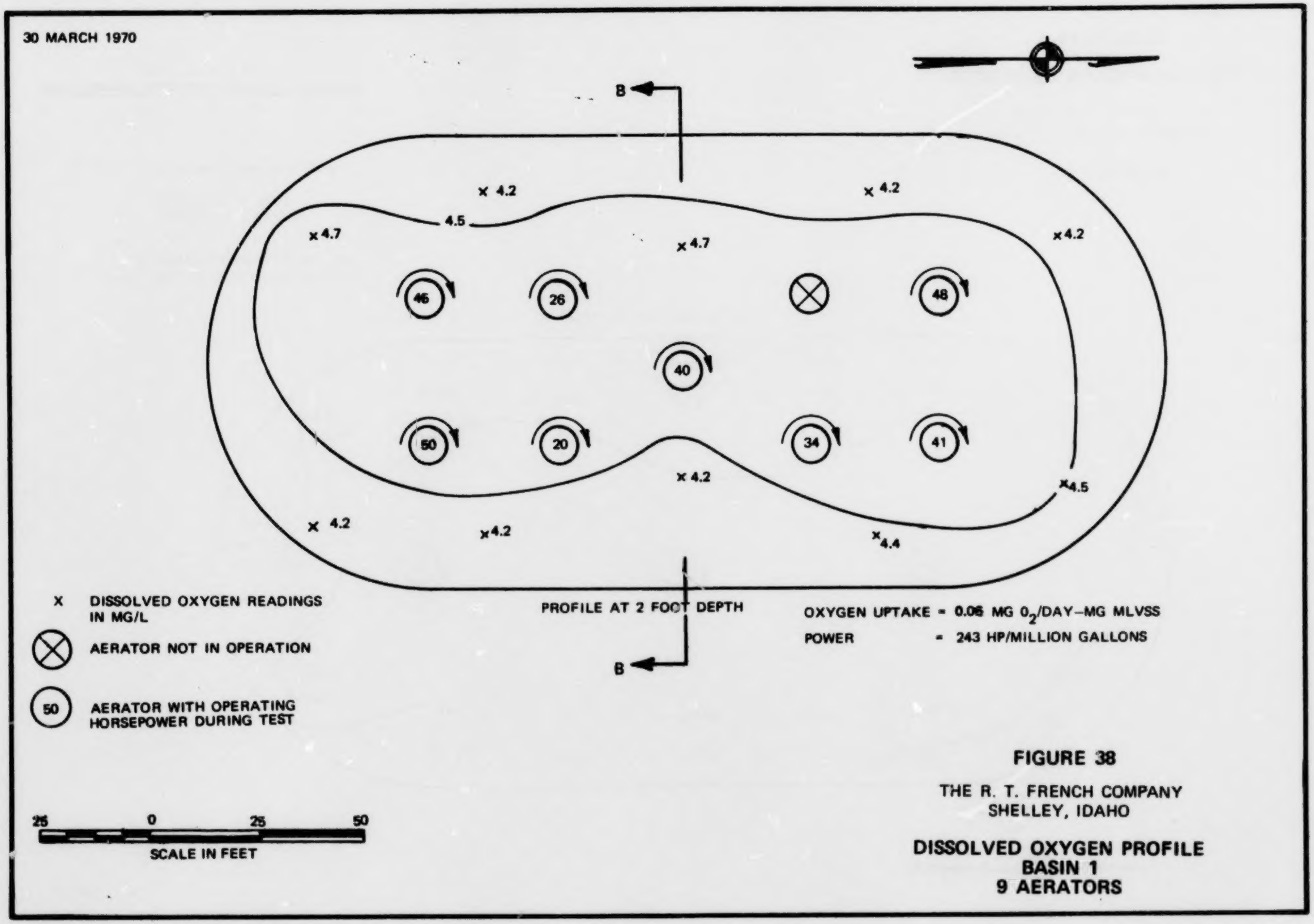

30 MARCH 1970
B
B
x 4.2
4.5
x 4.7
x 4.2
x 4.7
x 4.2
46
26
48
40
50
20
34
41
x 4.2
x 4.5
x 4.2
x 4.2
x 4.4
PROFILE AT 2 FOOT DEPTH
OXYGEN UPTAKE = 0.06 MG 0_2/DAY–MG MLVSS
POWER = 243 HP/MILLION GALLONS
X DISSOLVED OXYGEN READINGS IN MG/L
AERATOR NOT IN OPERATION
50 AERATOR WITH OPERATING HORSEPOWER DURING TEST
25
0
25
50
SCALE IN FEET

FIGURE 38

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 1
9 AERATORS

30 MARCH 1970

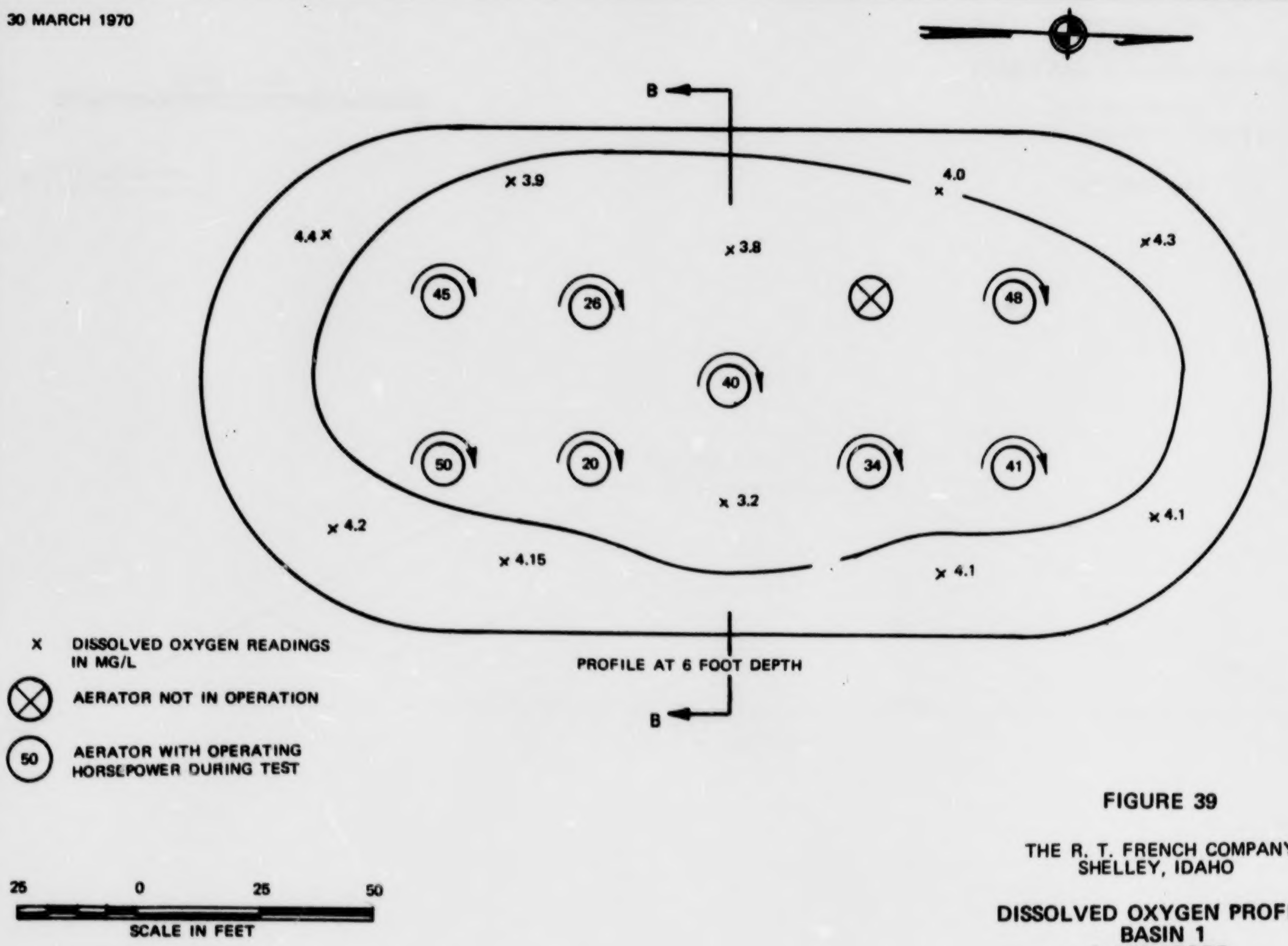

B
B
x 3.9
4.4 x
x 3.8
4.0
x
x 4.3
45
26
40
48
50
20
34
41
x 4.2
x 4.15
x 3.2
x 4.1
x 4.1
PROFILE AT 6 FOOT DEPTH
x DISSOLVED OXYGEN READINGS IN MG/L
AERATOR NOT IN OPERATION
50 AERATOR WITH OPERATING HORSEPOWER DURING TEST
25
0
25
50
SCALE IN FEET

FIGURE 39

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 1
9 AERATORS

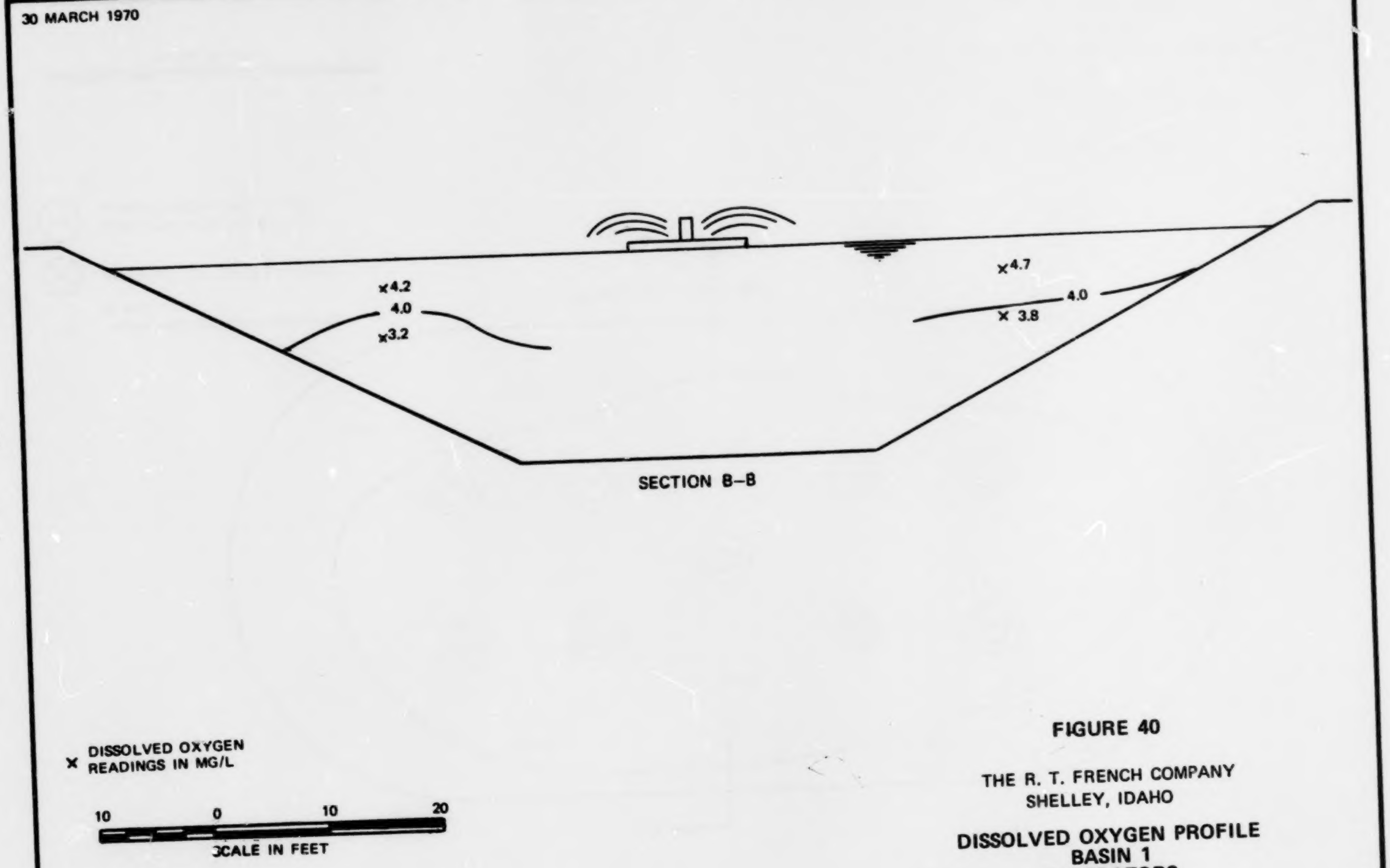

30 MARCH 1970
×4.2
4.0
×3.2
×4.7
4.0
× 3.8
SECTION B–B
× DISSOLVED OXYGEN READINGS IN MG/L
10
0
10
20
SCALE IN FEET

FIGURE 40

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 1
9 AERATORS

SOLIDS TREATMENT AND HANDLING

CLARIFIER-THICKENER–The clarifier-thickener was used to clarify silt water and a mixture of silt water and waste activated sludge. The primary function of the clarifier-thickener is to remove most of the abrasive silt from the silt water. Influent silt water suspended solids varied from 1,050 mg/l to 72,640 mg/l and averaged 13,240 mg/l. Suspended solids removal from the silt water is shown on Figure 41. Influent silt water BOD varied from 75 mg/l to 2,730 mg/l and averaged 770 mg/l. BOD removal is a side benefit and is shown on Figure 42.

Total suspended solids removals have approached 100 percent with silt water alone flowing through the clarifier-thickener. The average suspended solids removal was 72 percent. COD and BOD removals approached 80 percent. The noticeable variations in suspended solids removal and BOD removal are primarily the result of poor underflow pump performance which prevented frequent solids withdrawal. Waste activated sludge discharge to the clarifier-thickener also hindered silt settling and reduced removal efficiencies. Preliminary coagulation studies were conducted on clarification of silt water alone, and on a combination of silt water and waste activated sludge. Anionic polymers improved clarification of silt water alone, and cationic polymers improved the settleability of a mixture of silt water and waste activated sludge during bench scale testing; however, limited full-scale testing has not been very successful to date. Further testing is presently being conducted to optimize waste activated sludge-silt water mixing and polymer dispersion. Waste activated sludge was normally bypassed to the river.

The thickening capability of the clarifier-thickener is shown on Figure 43. The underflow solids level reached about 48 percent before being transferred to the vacuum filter for dewatering. Polymer additions increased the thickened solids concentrations.

VACUUM FILTRATION–The solids concentration of the clarifier-thickener underflow averaged about 48 percent and the vacuum filter cake averaged 62 percent solids without coagulants (Figure 43). When an anionic polymer was added to the silt water entering the clarifier-thickener, the underflow solids increased to about 53 percent and the filter cake solids increased to about 72 percent. The addition of waste activated sludge directly to the vacuum filter, while attempting to use the silt as a filter precoat, was not successful because the waste activated sludge only tended to wash off part of the silt cake, resulting in overall thinner sludge cakes. Spraying waste activated sludge on a preformed silt cake also resulted in thinner cakes.

The dewatered solids cake became more concentrated with more dilute clarifier-thickener underflow solids concentrations; however, the dewatered cake was thinner, resulting in lower filter loading rates.

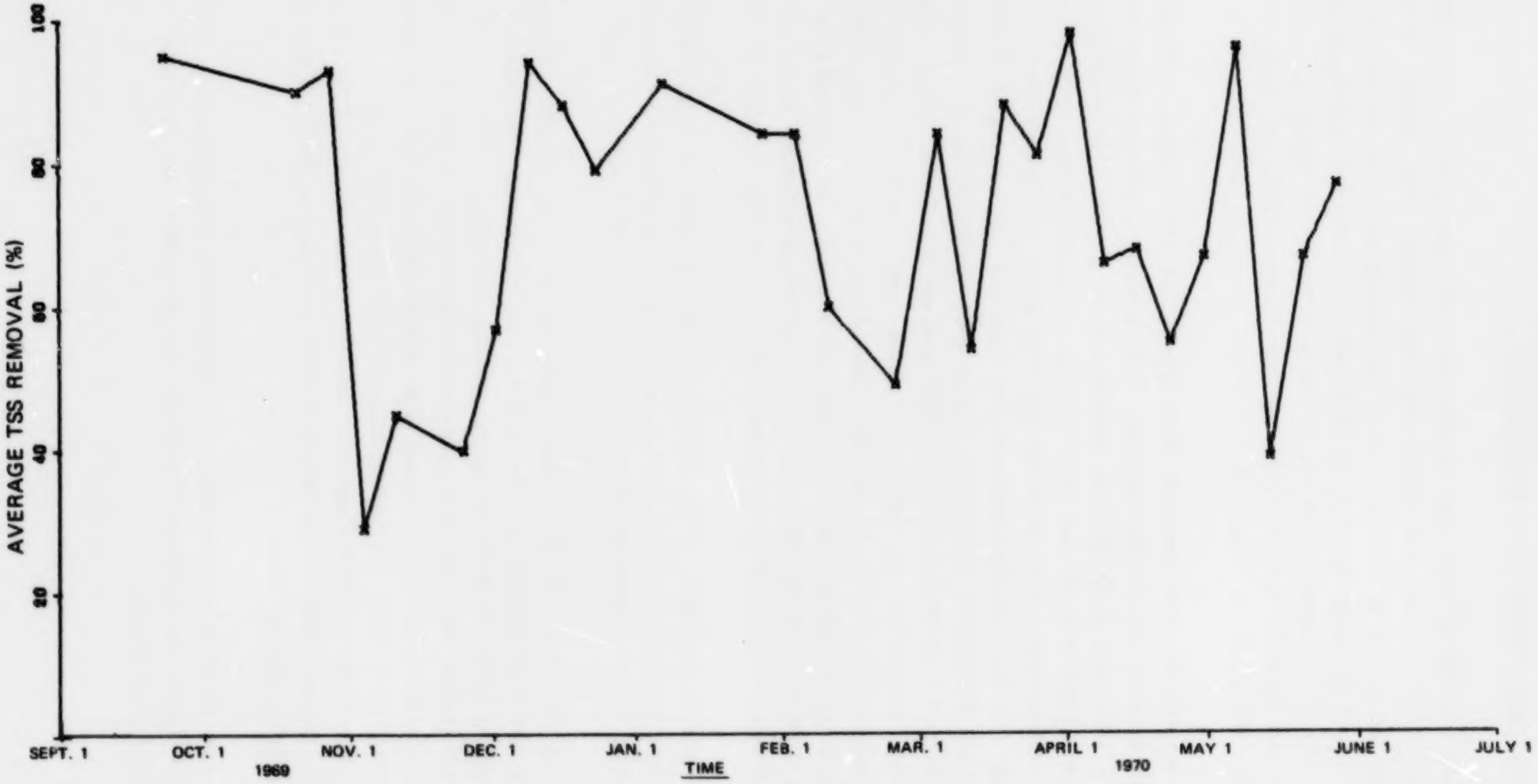


FIGURE 41

AVERAGE TSS REMOVAL VS. TIME
(CLARIFIER – THICKNER)

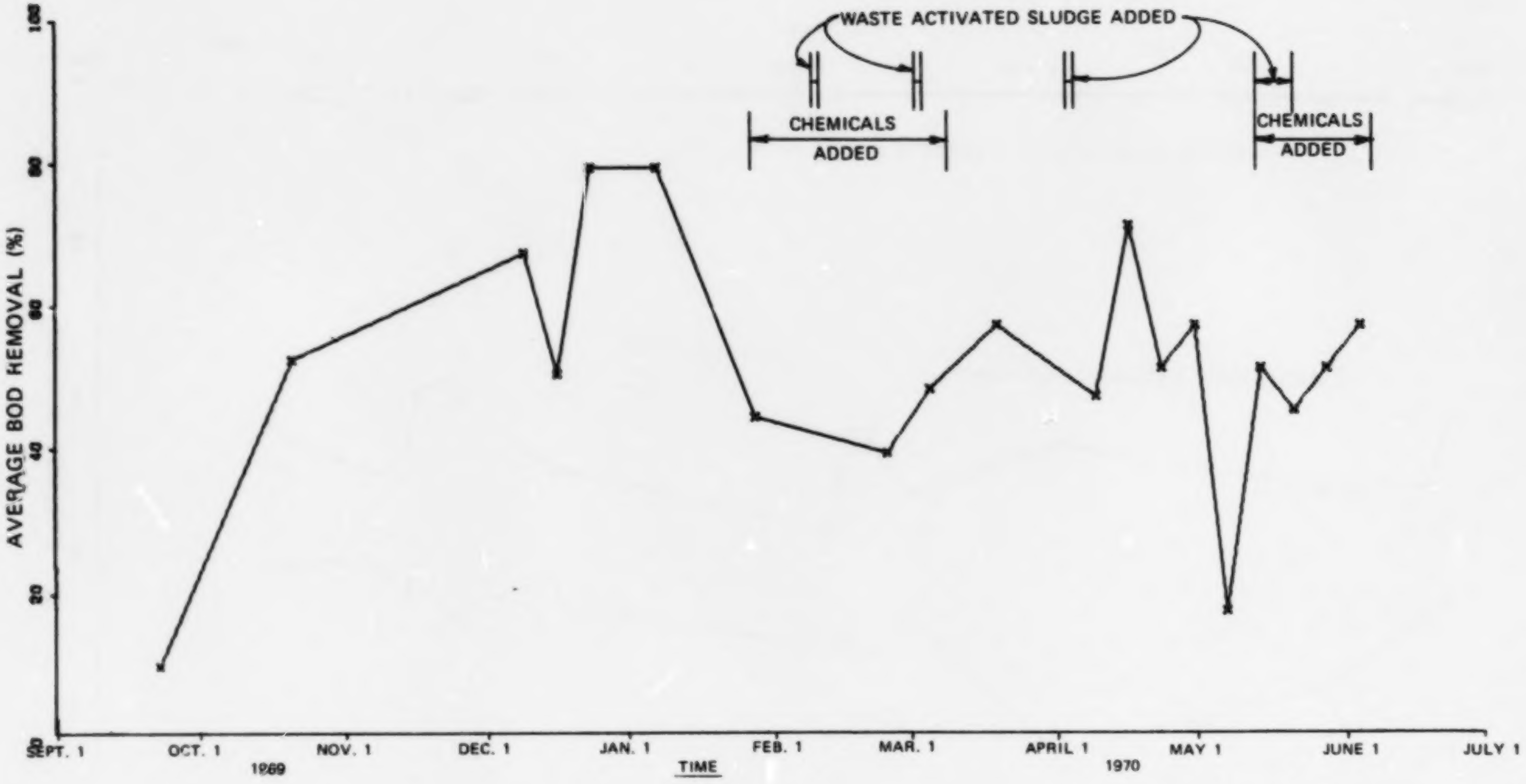


FIGURE 42

AVERAGE BOD REMOVAL VS. TIME
(CLARIFIER – THICKNER)

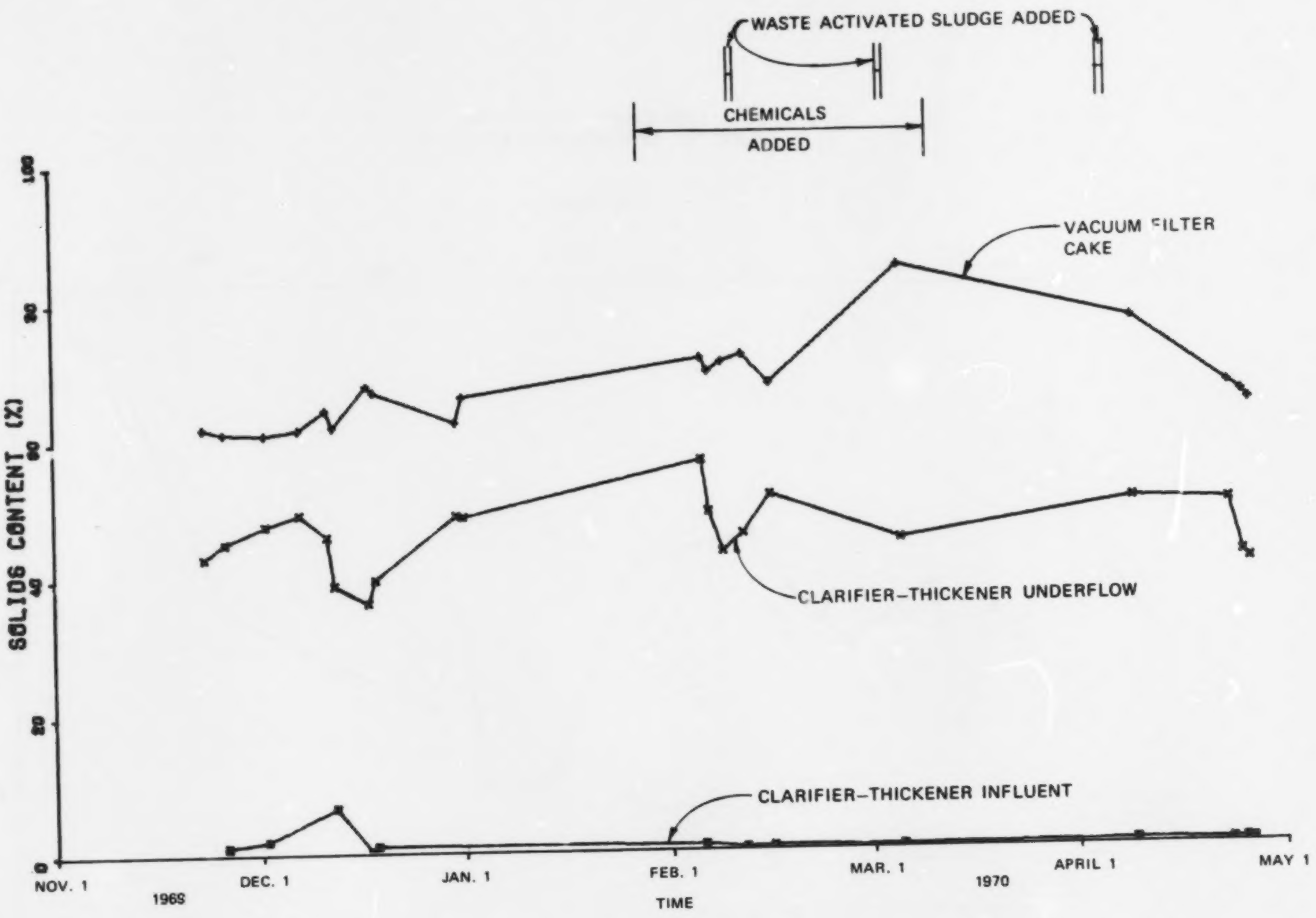


FIGURE 43

SOLIDS CONCENTRATION AND DEWATERING

DEWATERED SOLIDS HANDLING–The dewatered silt solids were very acceptable as landfill. During the 1969-70 processing season, most of the waste silt solids were used to fill in low areas around the plant site. Excess waste silt solids were hauled to a local sanitary landfill. This practice has been continued during the 1970-71 processing season.

SECTION IX
OPERATING PROBLEMS

MECHANICAL PROBLEMS

Numerous mechanical problems were encountered at the secondary waste treatment facility, and as a result, problems developed within the biological and physical treatment processes. Some of the major mechanical problems are discussed below, along with attempted solutions to these problems.

AERATION BASINS–The following listed problems were encountered with equipment and materials used with the aeration basin:

1. The Hypalon basin-top lining would not stay below the water surface and, as a result, it caught in the wind and tore in several places. Pieces of the lining caught in the aerators. The problem was solved by removing the remaining lining and replacing it with a rock surface.

2. The PVC basin linings failed and pieces of the linings caught in the aerators. The linings were replaced and covered with rock on the basin bottom and on the side slopes in the wave action area. Basin 1 lining failed again near the beginning of the 1970-71 processing season, but the extent of the failure will not be assessed until the processing plant shuts down in June.

3. The floating mechanical aerators frequently: (1) overdrew amperage and shut off, (2) had bearing failures, and (3) developed loose hardware. The aerator manufacturer determined that these problems were the result of high velocity axial flow entering the aerator intake. The manufacturer recently installed an intake cone with a baffle plate in the center of the intake on each of the aerators, which appears to have solved the problems.

SECONDARY CLARIFIER - WASTE SOLIDS PUMP–The sludge withdrawal mechanism rotation was jerky until the seals were adjusted and additional structural bracing was installed.

The waste sludge pump became inoperable when the waste sludge line had become filled with sand from grout on the clarifier bottom. The problem was solved by replacing the pump stator and cleaning the waste sludge line.

CLARIFIER-THICKENER–Frequent clarifier-thickener underflow pump breakdowns resulted in excessive silt concentration in the bottom cone, and hardened silt prevented rotation of the rake mechanism. A silt recycle system was installed to allow frequent silt removal and rubber scrapers were installed on the rakes to limit the reoccurrence of this problem. The underflow pump manufacturer provided air chambers for the suction and discharge sides of the pump to relieve excessive pump strain; however, breakdowns still occur, and additional analysis is planned to eliminate this problem.

VACUUM FILTER–Several problems encountered with the vacuum disc filter are listed below:

1. The rubber scrapers did not remove the solids cake from the cloth media. Stainless steel media with plastic scrapers were installed to remedy this problem. This has proven successful.

2. Limited funds required housing the vacuum filter in the control building. This has resulted in a noisy control building and laboratory. Placing the exhaust muffler underground relieved the external noise and resident complaints. Internal noise will be reduced to an acceptable level with insulation.

3. Dewatered silt and sludge conveying was hampered by excessive wear of the screw conveyor hanger bearing and stub shaft. A new belt conveyor was installed to replace the screw conveyor.

PROCESS PROBLEMS

Problems encountered in the activated sludge process have been primarily associated with sludge bulking. This has occurred several times and appears to be related to frequent aerator problems, with accompanying large fluctuations in D. O. levels. Recycling of waste activated sludge through the clarifier-thickener, where removal efficiencies were poor, resulted in increased aeration basin suspended solids levels and reduced D. O. levels. Increased D. O. levels and reduced influent BOD to basin MLVSS ratios have been successfully used to eliminate the bulking sludge when it appeared; however, the last occurrence of bulking sludge (last part of April) was not controlled by these methods. At the close of the processing season, a sludge sample was sent to nearby Ricks College and was reported to contain a filamentous fungus (Appendix E). Subsequent pilot plant studies indicated that the fungus can be controlled with a fungicide, potassium sorbate, and that it can be eliminated by starvation (continuous aeration without food) in less than two weeks.

Foaming has occurred on the aeration basins at low MLSS levels, but has not been a problem at MLSS levels above 2,000 mg/l and a D. O. above 1.5 mg/l.

Addition of an anionic polymer to the silt water, ahead of the clarifier-thickener, has improved the silt removal efficiency. Polymers have not been found effective on full-scale, combined waste activated sludge-silt water clarification and thickening in the clarifier-thickener. Preliminary laboratory testing with cationic polymers has, however, looked promising. Additional coagulation testing is being conducted at this time under the sponsorship of the Potato Processors of Idaho Association.

SECTION X
FINANCIAL CONSIDERATIONS

CONSTRUCTION COSTS

The total capital cost for construction of the secondary wastewater treatment facility was \$598,105. A detailed cost breakdown is presented in Appendix F. About 28 percent, or \$167,000, of this cost is estimated to be attributable to providing additional facility capabilities to carry out the demonstration project.

OPERATION AND MAINTENANCE COSTS

The first season's operation and maintenance costs for the secondary wastewater treatment facility were \$93,212. A detailed cost breakdown is provided in Appendix F. Approximately 22 percent (\$20,950) of the total operation and maintenance costs are estimated to be the result of the first-year demonstration project, which required additional sampling, testing, supervision, and data analysis.

Reported solids disposal costs were low during the 1969-70 processing season because most of the waste silt solids were used to fill in low areas around the plant site and waste activated sludge was discharged to the river. Waste silt solids are being hauled to a local sanitary landfill this year for a cost of \$1,000 per month or about \$3.30 per cubic yard. Disposing of the waste activated sludge and all of the silt by this method during the 1969-70 season would have cost about \$14,000 more than the reported costs. This would have resulted in a total operating and maintenance cost of about \$86,300, excluding the first-year demonstration costs.

Michael [8] reported annual operation and maintenance costs for activated sludge plants (secondary treatment only) sized for a population equivalent of 85,300 people (14,500 pounds of BOD per day) to range from \$80,000 to \$400,000 per year. The average reported cost was \$180,000 per year. On the basis of a season lasting about 9 months, these reported figures would range from \$60,000 to \$300,000, with an average of \$135,000. These costs were reported for 1965-67 and should be increased by at least 15 percent to arrive at comparable 1969-70 costs. The updated cost range would be from \$69,000 to \$345,000, with an average of \$155,000 per season. The operation and maintenance costs at R. T. French during the 1969-70 processing season, excluding the demonstration expenses, were about \$72,300 (Appendix F), which is on the low end of the range reported for municipal activated sludge plants.

TOTAL ANNUAL COSTS

Total annual treatment costs can be shown to be equal to the sum of: (1) annual capital amortization costs (7 percent interest for 20 years), (2) annual operation and maintenance costs, and (3) equipment replacement and depreciation costs (5 percent of equipment capital cost). Table 5 contains treatment cost estimates for the demonstration year (1969-70 season) with and without the demonstration costs. On the basis of these elements, the unit treatment costs of the demonstration year were about $0.049 per pound of BOD applied, or $0.027 per pound of COD applied. The estimated costs, excluding demonstration costs, are $0.038 per pound of BOD applied, or $0.021 per pound of COD applied. Both season's unit cost estimates are based on the waste load during the 1969-70 season, or 3,335,000 pounds of BOD and 6,064,000 pounds of COD.

TABLE 5
SECONDARY TREATMENT COSTS

ITEM	TOTAL 1969-70 SEASON	ESTIMATED 1969-70 SEASON WITHOUT DEMONSTRATION
Construction Cost	$598,105	$431,379
Amortized Capital Cost (7% - 20 years)	56,500	40,700
Annual Operation & Maintenance Cost	93,200	72,300
Estimated Equipment Replacement & Depreciation (5% of Equipment Cost)	15,000	15,000
Total Annual Cost	$164,700	$128,000
Estimated Cost of Treatment		
(3,335,000 lb BOD/year)	$0.049/lb BOD Applied	$0.038/lb BOD Applied
(6,064,000 lb COD/year)	$0.027/lb COD Applied	$0.021/lb COD Applied

These total annual cost estimates are lower than costs reported for activated sludge treatment of fruit processing wastes [9]. Activated sludge treatment of fruit wastes were estimated to be $0.061 per pound of BOD removed or $0.048 per pound of COD removal. Assuming 95 percent BOD removal and 90 percent COD removal, the reported costs would be $0.058 per pound of BOD applied or $0.043 per pound of COD applied.

The lower unit cost at R. T. French is probably due to the greater annual organic load experienced. Lower unit treatment costs are frequently associated with systems receiving larger waste loads.

Adding extra sludge disposal costs ($14,000) to the estimated 1969-70 total annual costs at R. T. French, without demonstration costs, would result in unit treatment costs of $0.043 per pound of BOD applied and $0.023 per pound of COD applied.

SECTION XI
DISCUSSION

ACTIVATED SLUDGE SYSTEM

MICROBIOLOGY–Treatment system operation was the most efficient when the activated sludge contained a high population of stalked ciliates and a moderate population of free-swimming ciliates. Some filamentous growth was usually present in the sludge; however, during periods of efficient operation, it was present only in limited quantities. These findings are in agreement with the findings of many other researchers [1,2,10,11]. Photomicrographs of the activated sludge during normal operation and during periods of sludge bulking are shown on Figure 44.

Ciliates which were identified in the activated sludge include *Vorticella microstoma, Vorticella campanula, Lionotus species, and Paramecium.* The best effluent was produced when *Vorticella campanula* was the predominant *Vorticella.*

During extended periods of low dissolved oxygen, filamentous growth, either bacteria or fungi, seemed to dominate the activated sludge as shown in the left-hand photomicrograph of Figure 44.

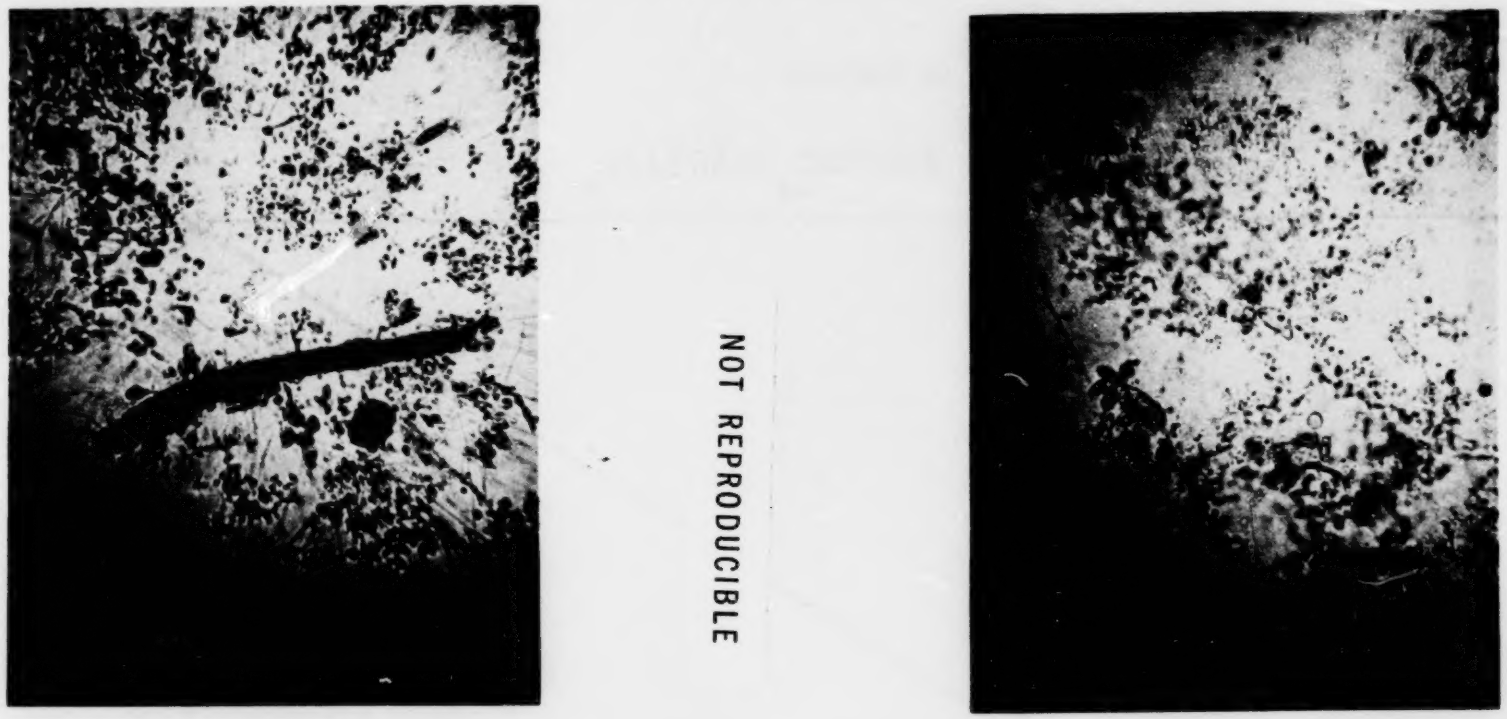
SUBSTRATE REMOVAL–The substrate utilization equation presented in Section V is shown below:

$$\frac{S_r}{X_a t} = kS_e$$

If the total weight of BOD removed per day per unit weight of MLVSS is plotted against the effluent soluble BOD, the slope of the first order curve passing through (0,0) will be equal to the BOD removal rate coefficient, k. Figures 45, 46, and 47 are plots of BOD removal versus effluent soluble BOD at the three temperature ranges in which the system operated when working efficiently. The lines were passed through (0,0) and the mean coordinates. Figure 46 has considerable scatter, which is not unusual for field data.

Figure 48 is a semi-logarithmic plot of the BOD removal rate coefficient, k, versus the average basin temperatures obtained from the figures described above. The equation of the straight line can be used to determine BOD removal rate coefficients at various temperatures. The equation is:

$$k = 0.016 \times 1.17^{(T-20)}$$



NOT REPRODUCIBLE

FILAMENTOUS ACTIVATED SLUDGE
(100X)

NORMAL ACTIVATED SLUDGE
(100X)

FIGURE 44

PHOTOMICROGRAPHS OF ACTIVATED SLUDGE

B4435.3

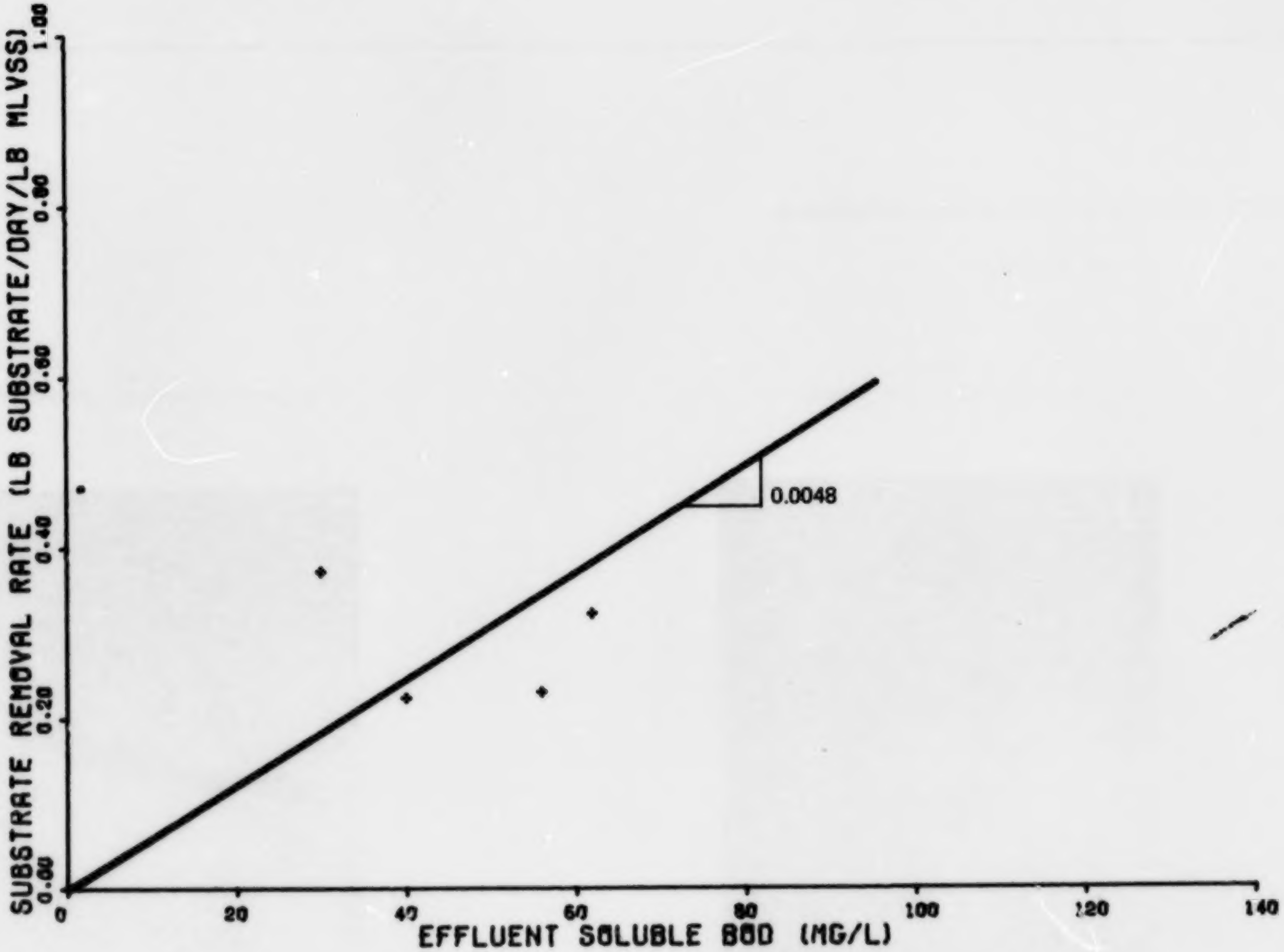


FIGURE 45

EFFLUENT SOLUBLE BOD VS. SUBSTRATE REMOVAL
TEMPERATURE EQUALS 50 TO 55 °F
(SELECTED DATA)

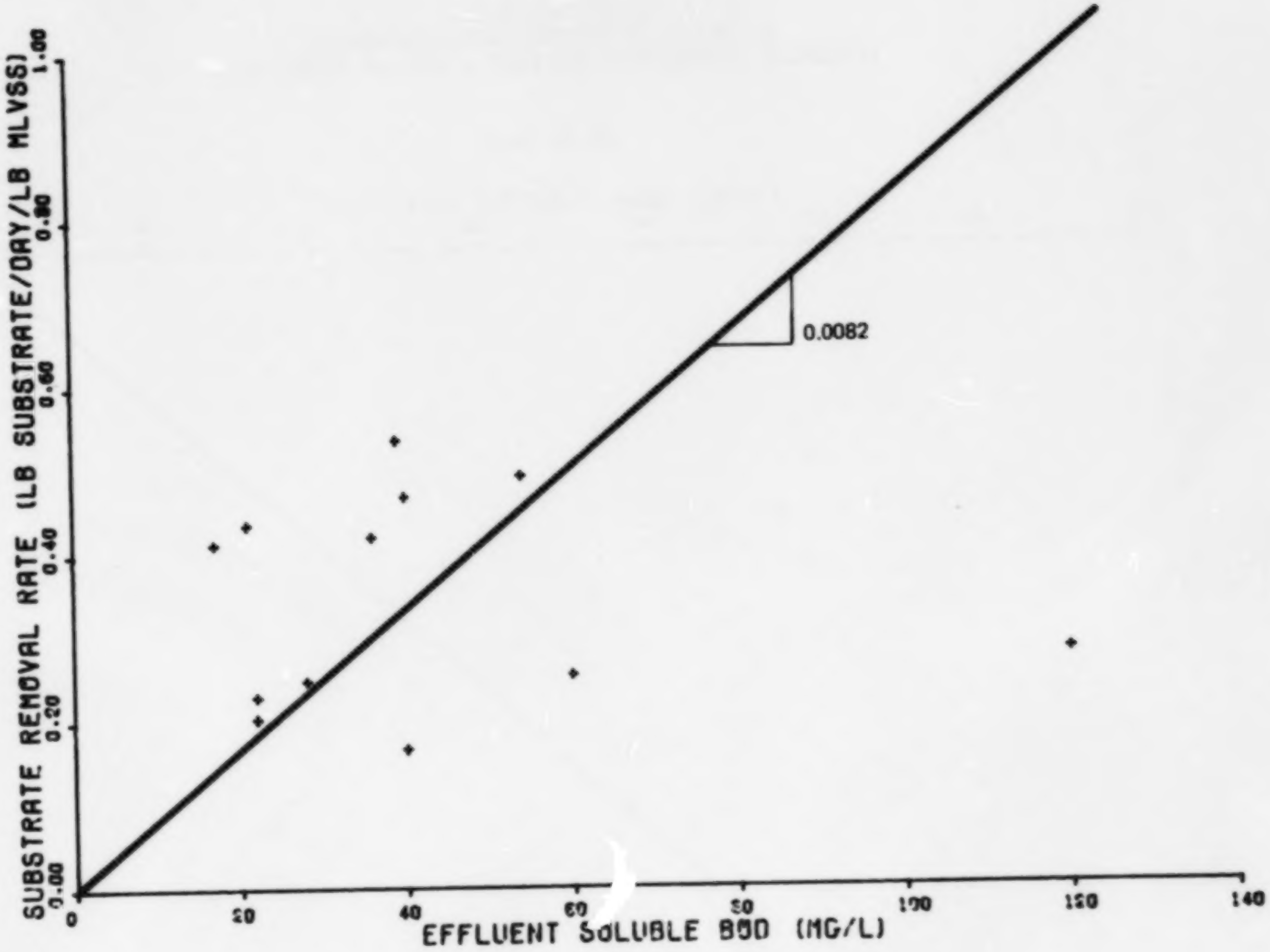


FIGURE 46

EFFLUENT SOLUBLE BOD VS. SUBSTRATE REMOVAL
TEMPERATURE EQUALS 58 TO 60 ^{o}F
(SELECTED DATA)

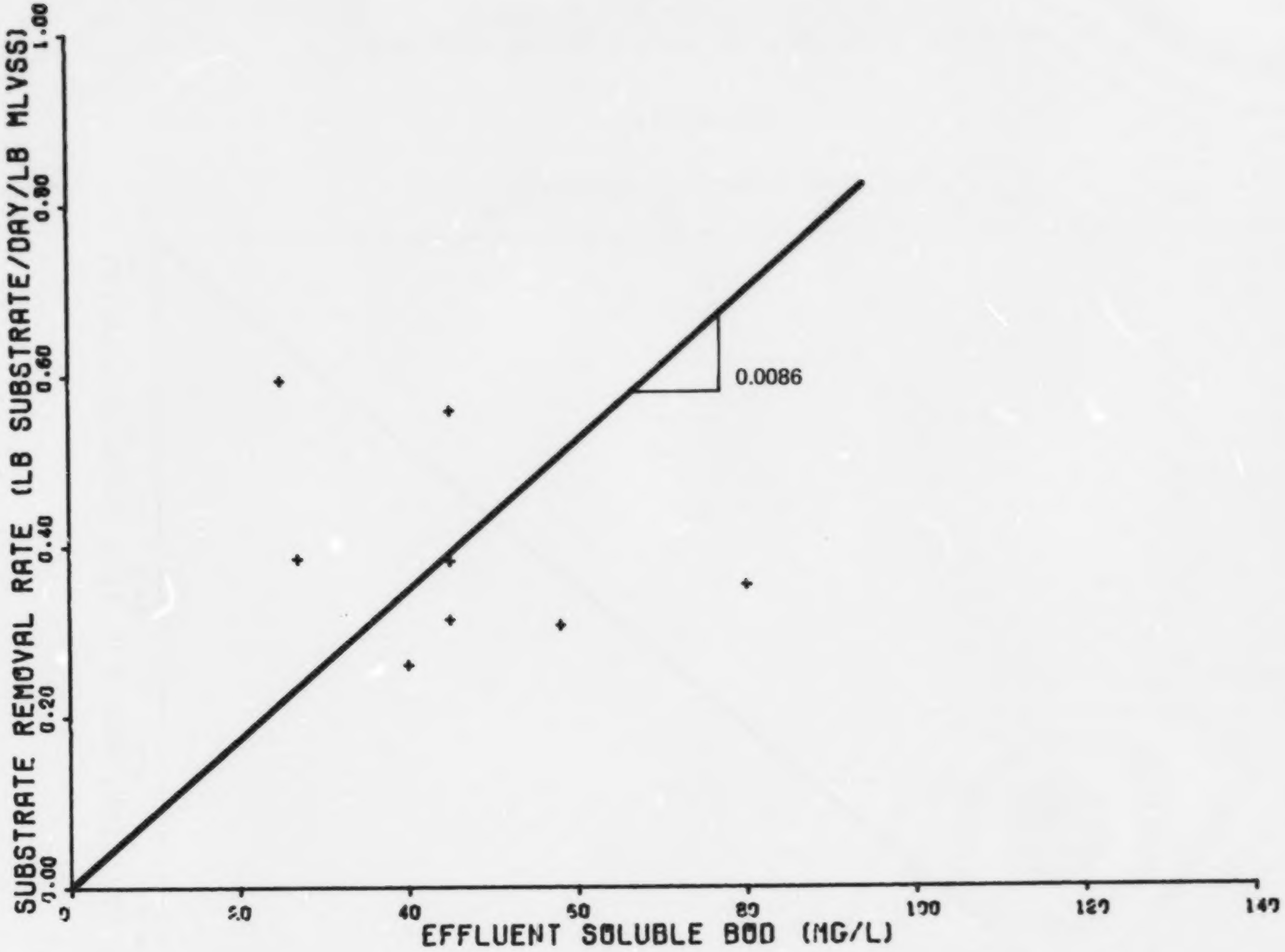


FIGURE 47

EFFLUENT SOLUBLE BOD VS. SUBSTRATE REMOVAL
TEMPERATURE EQUALS 61 TO 63 °F
(SELECTED DATA)

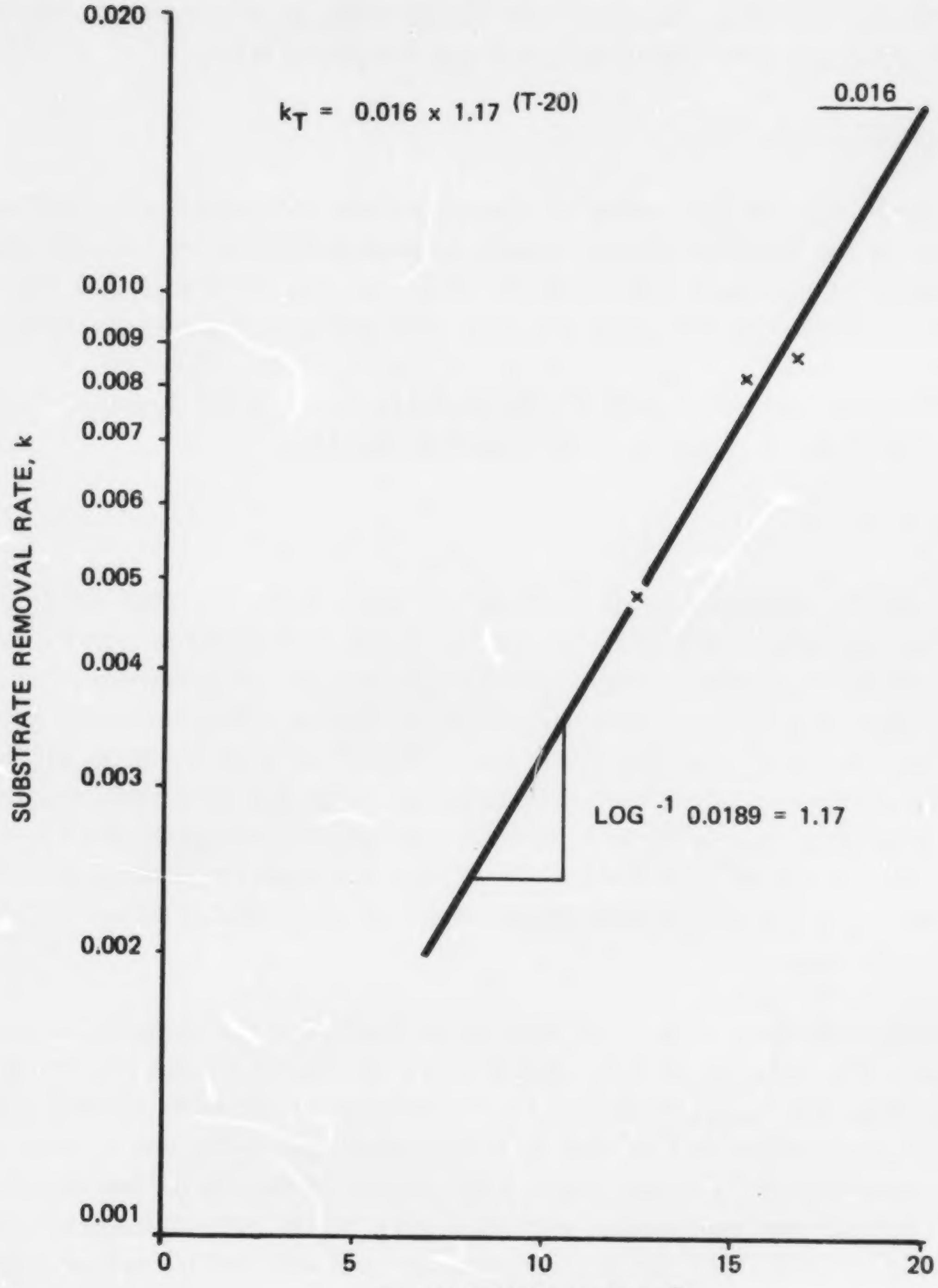


FIGURE 48

SUBSTRATE REMOVAL RATE VS. TEMPERATURE

SLUDGE YIELD–An equation expressing net sludge yield in a completely mixed activated sludge system was presented in Section V and is repeated below:

$$\Delta X_v = fS_o + aS_r - bX_d$$

This equation shows that the net change in average MLVSS concentrations should be equal to the sum of the non-biodegradable volatile suspended solids in the influent plus the volatile fraction of biological cells produced while removing BOD from the waste material, minus the volatile fraction of the biological cells used in endogenous respiration.

The fraction of volatile suspended solids in plant influent, which is not degradable, has been assumed to be negligible, resulting in the following equation:

$$\Delta X_v = aS_r - bX_d$$

A plot of net volatile suspended solids produced per day, ΔX_v, per unit weight of MLVSS versus the quantity of BOD removed per day, S_r, per unit weight of MLVSS was made for each of two temperature ranges with enough data to plot a first-order curve (Figures 49 and 50). Even then, the field data included sufficient scatter to require prior knowledge of the direction that the straight line should be plotted. Both sets of temperature data represented about the same sludge age range, and as a result, straight lines with the same slope, a, seemed to fit both sets of data. The sludge synthesis yield coefficient, a, is shown as 0.88. The Y-axis intercept, which is equal to net sludge growth at zero BOD removal or the rate of endogenous respiration (auto-oxidation) per day, b, was different in each case.

Figure 51 is a semi-logarithmic plot of the endogenous respiration rate, b, versus average basin temperature. The data for the two points shown on Figures 49 and 50, and the semi-logarithmic plot was chosen because of the tendency of the BOD removal rate coefficient versus temperature plot to vary in a semi-logarithmic order, and because of other reported experience [9] in evaluating b. The equation of the straight line plot can be used to determine the endogenous respiration rate, b, at various temperatures; however, it should be understood that the variability of field data and the narrow range of aeration basin operating temperatures did not allow verification of this equation over a wide range of temperatures. The equation is:

$$b_T = 0.19 \times 1.31^{(T-20)}$$

The sludge synthesis yield coefficient, a, presented above is slightly above other published data [6,9,11], which indicates the presence of non-biodegradable volatile suspended solids in the influent. The rate of endogenous respiration, b, corresponds to other published

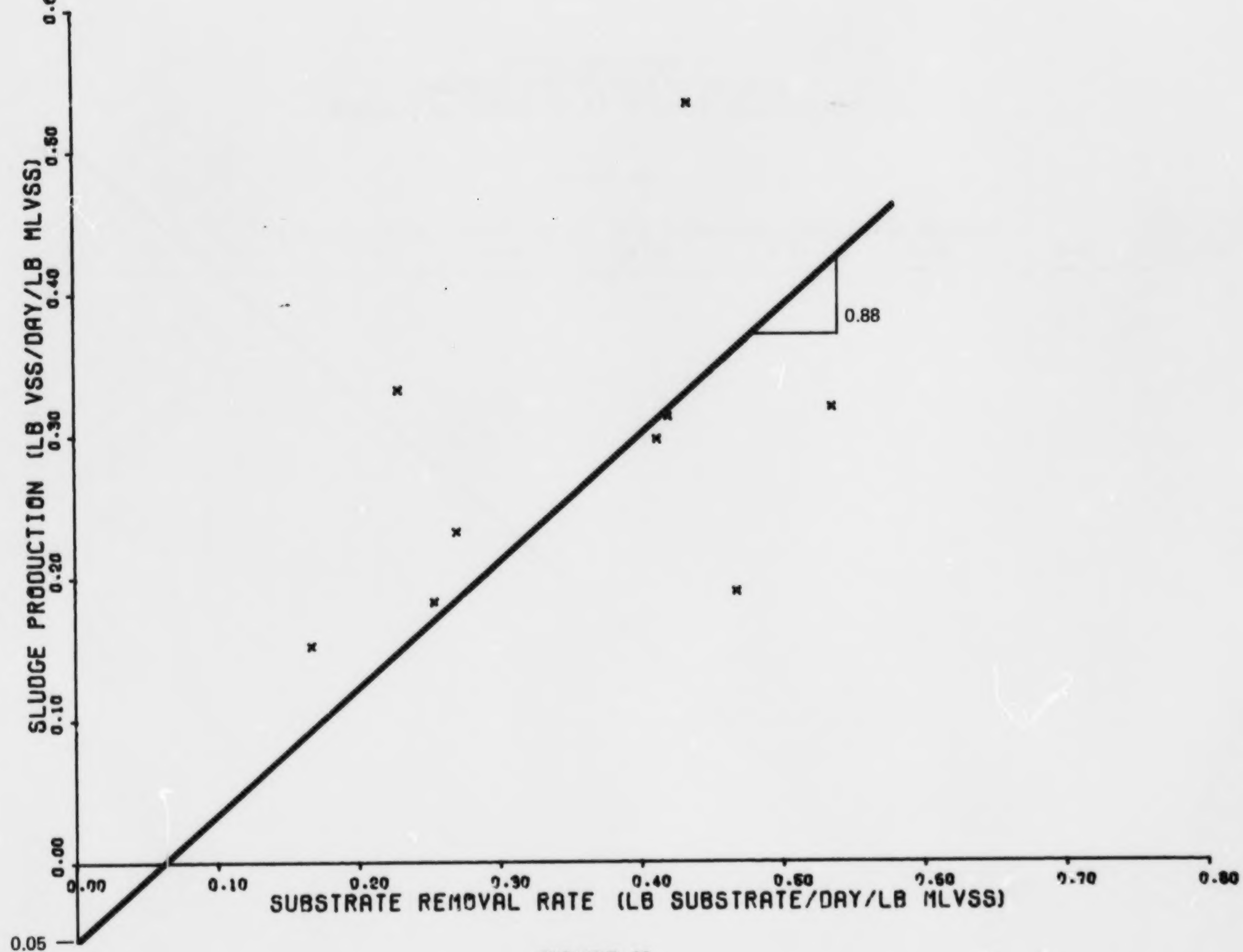


FIGURE 49

SUBSTRATE REMOVAL VS. SLUDGE PRODUCTION
TEMPERATURE EQUALS 58 TO 60 F
SELECTED DATA

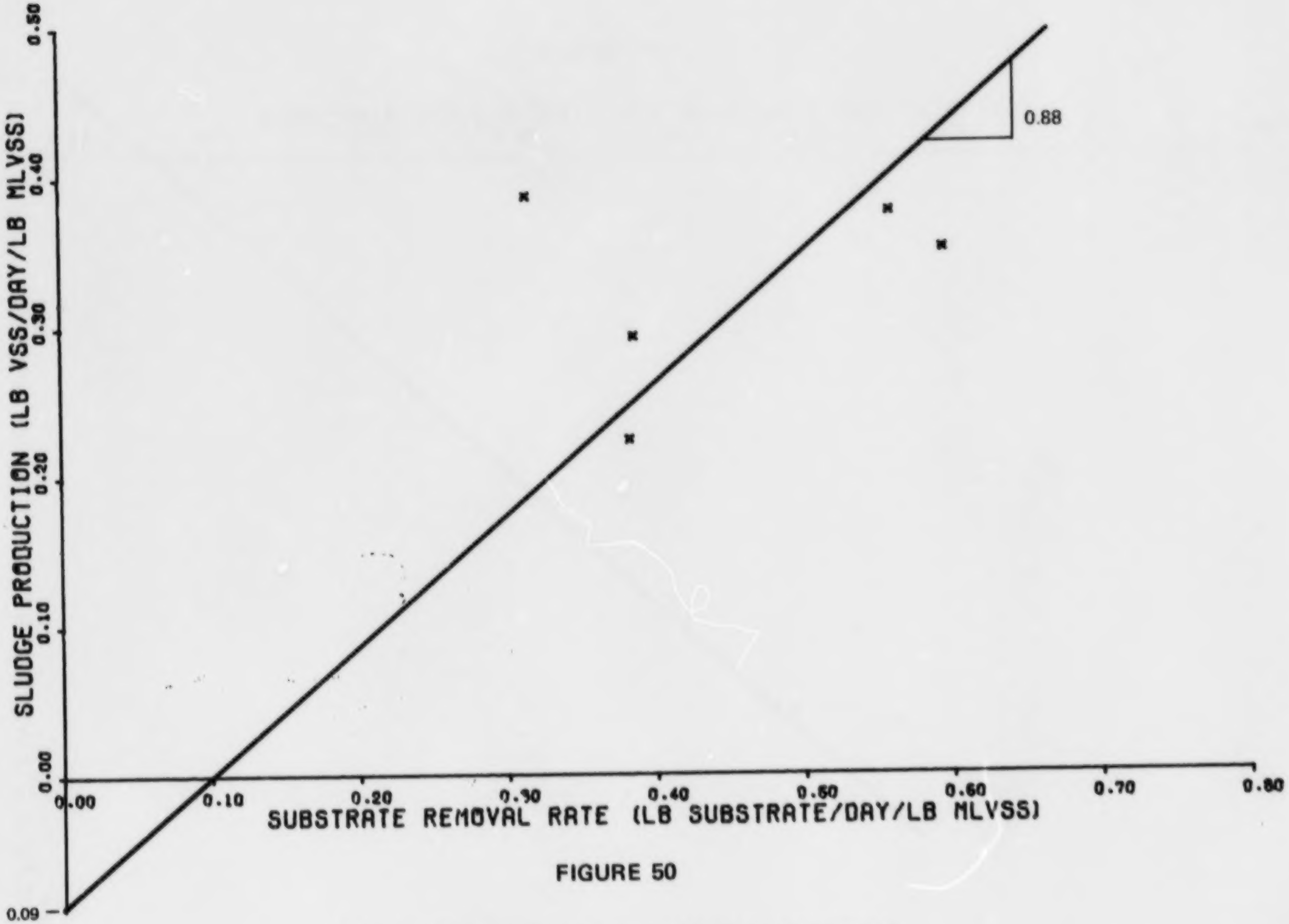


FIGURE 50

SUBSTRATE REMOVAL VS. SLUDGE PRODUCTION
TEMPERATURE EQUALS 61 TO 65 F
SELECTED DATA

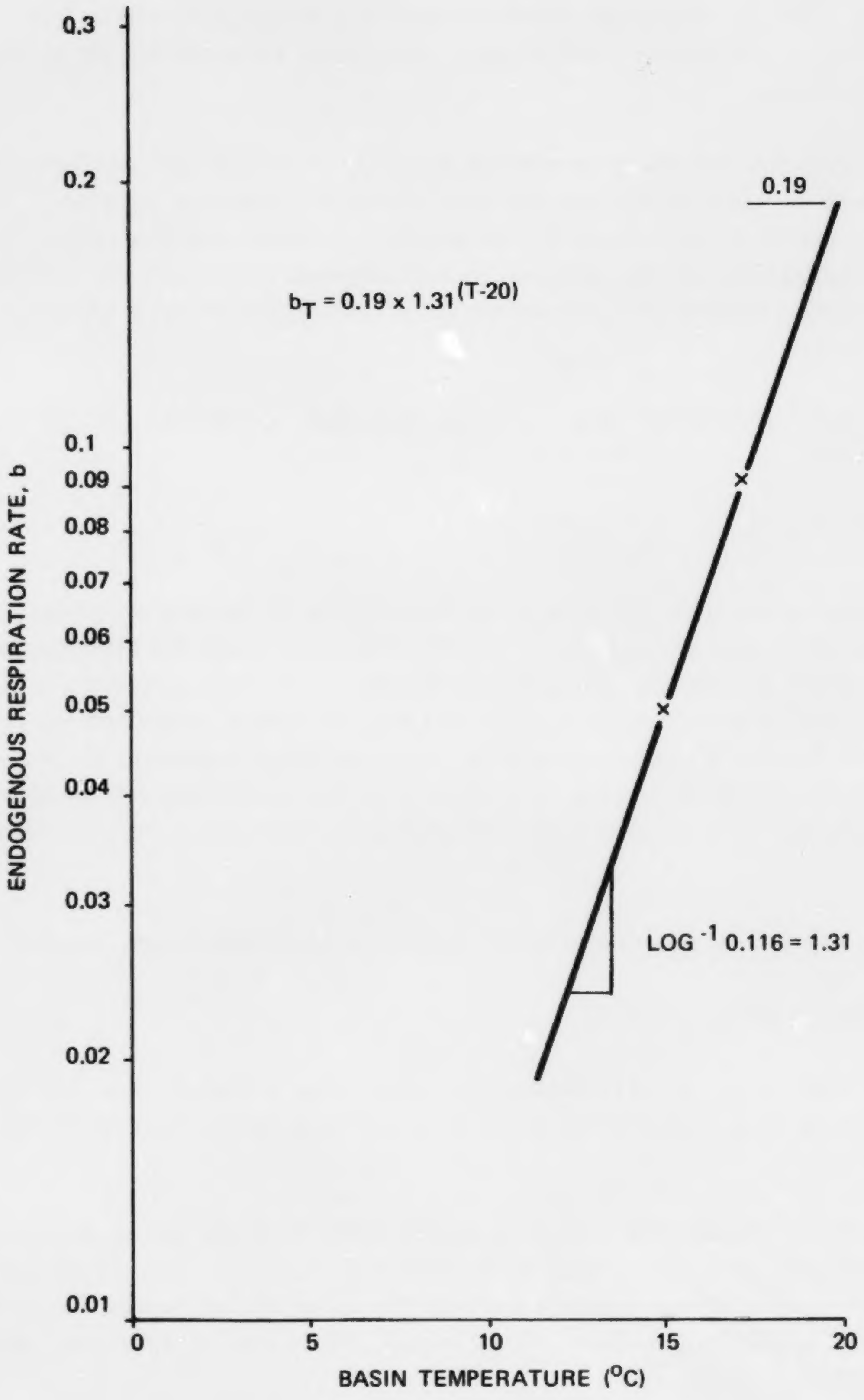


FIGURE 51

ENDOGENOUS RESPIRATION RATE VS. TEMPERATURE

data [6,9,11], but the correlation between b and basin temperature appears high. This is probably because the narrow aeration basin temperature range limited the number of points for Figure 51.

Figure 52 shows that net sludge production decreases with sludge age; therefore, systems operating with a longer sludge age will have less waste sludge for disposal. This is a general plot and does not include the temperature variations described above. The net sludge production rates include influent volatile suspended solids and are in agreement with other data published [6,9,11] on treatment of wastewaters with influent volatile suspended solids.

OXYGEN REQUIREMENTS–The equation presented in Section V for oxygen requirements is:

$$O_2 = a' S_r + b' X_d$$

System oxygen uptake rate data is included in Appendix G. Plotting the oxygen uptake rate (weight of O_2 used per day per unit weight of MLVSS) versus the BOD removal rate (weight of BOD removal per day per unit weight of MLVSS) provided a first-order least-square curve (Figure 53). The equation of the curve is equal to the total oxygen use, the slope of the line is equal to a' and the Y-axis intercept is equal to b', the oxygen utilization rate when BOD removal is equal to zero. The coefficient a' is equal to 0.48 and the coefficient b' is equal to 0.03. This plot is for temperatures between 52 and 60 degrees F.

The oxygen requirement equation, with the determined coefficient values, becomes:

$$O_2 = 0.48 S_r + 0.03 X_d$$

The determined value of a' compares favorably with published data [9,11]. The determined value of b' is slightly below the same published data because of the low basin temperature range.

BOD AND SUBSTRATE REMOVAL RELATIONSHIPS–Data obtained during periods of efficient operation have been analyzed to determine the effect that certain operating parameters had on BOD and substrate removal. The curves are least-square fits of weekly average data by computer. Each of the curves takes into consideration only the referenced variables.

Figure 54 shows that BOD removal increased slightly with higher average aeration basin dissolved oxygen levels, while operating between the range of 0.6 to 2.8 mg/l dissolved oxygen.

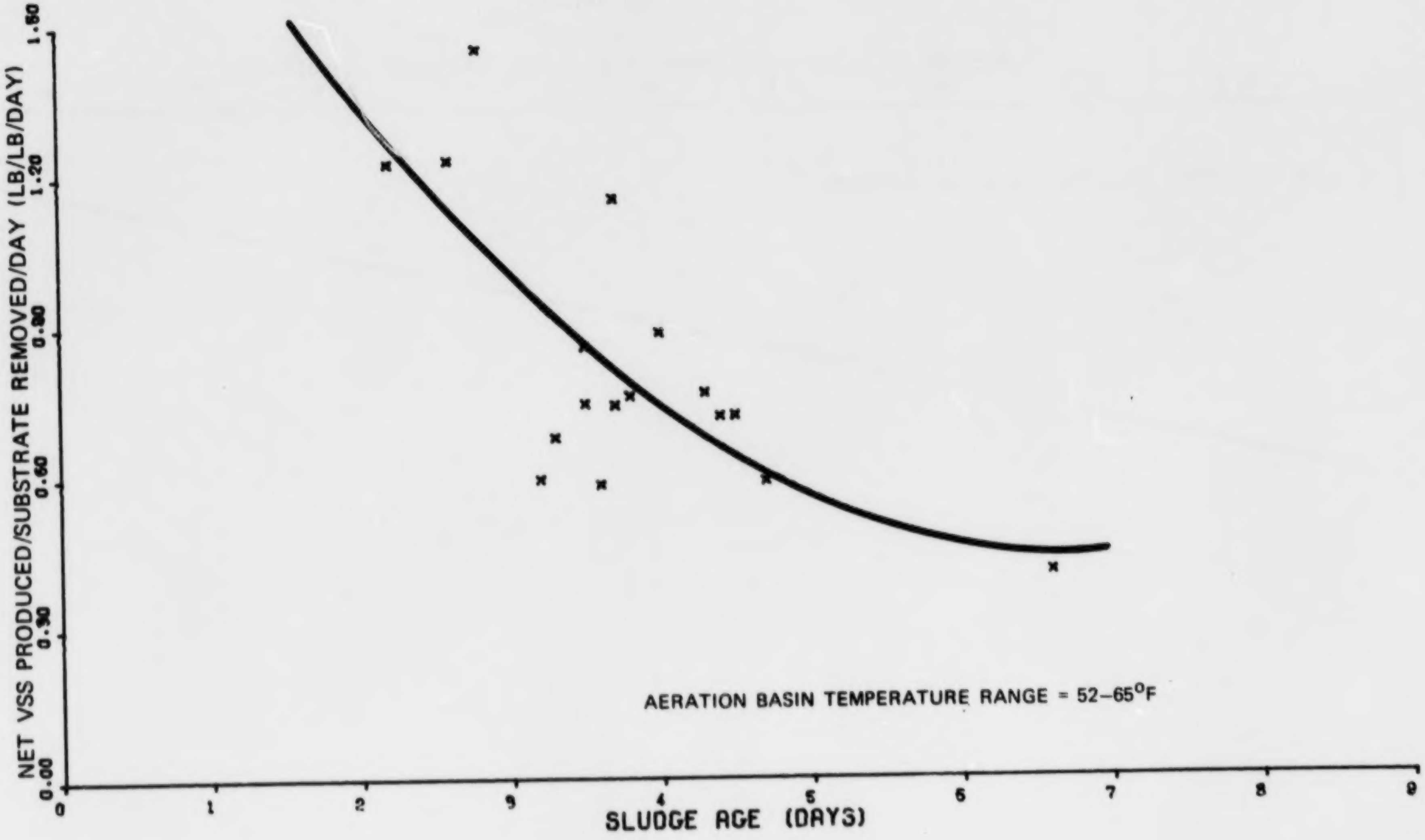


FIGURE 52

SLUDGE AGE VS. SLUDGE PRODUCTION
(SELECTED DATA)

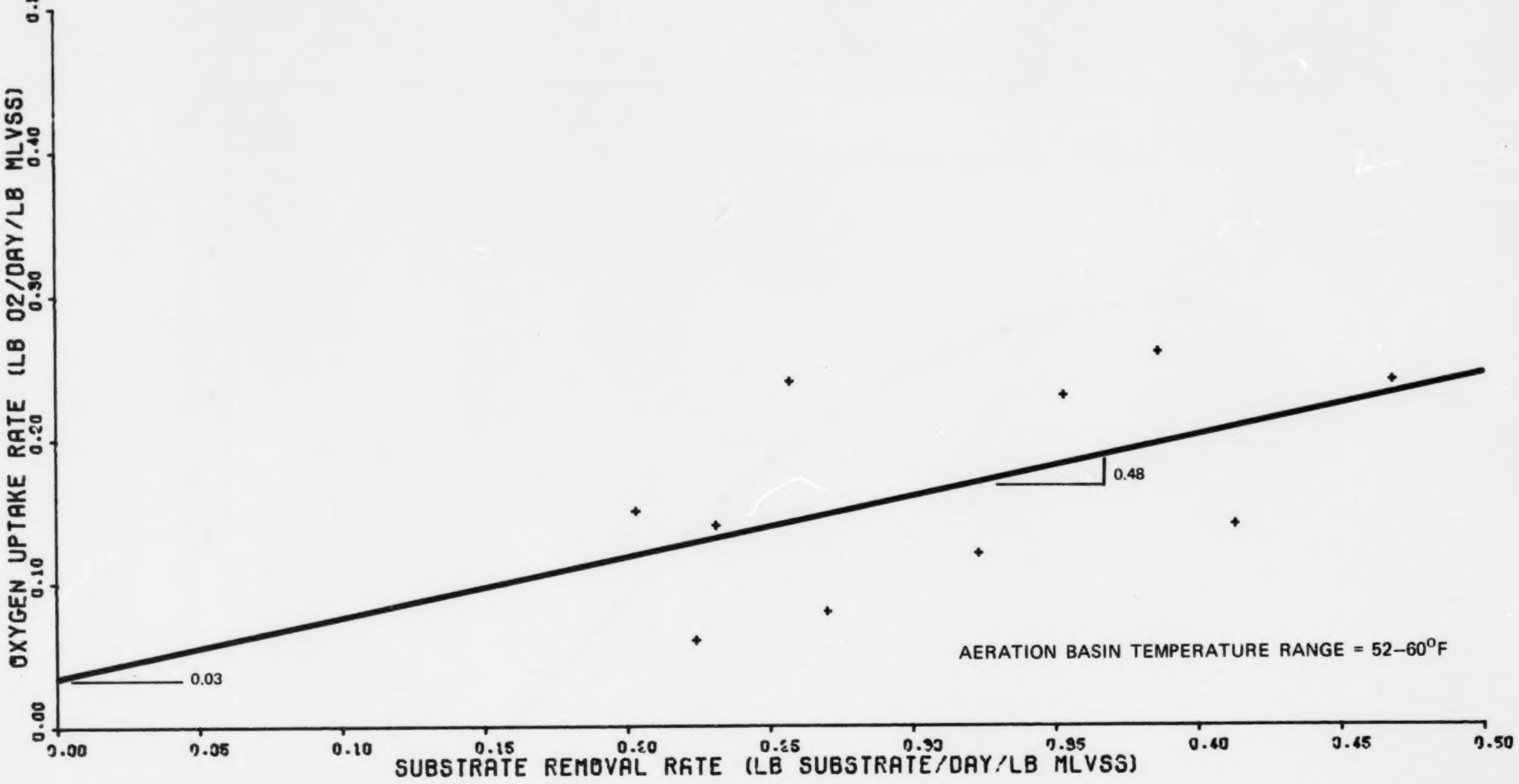


FIGURE 53

OXYGEN UPTAKE RATE VS. BOD REMOVAL

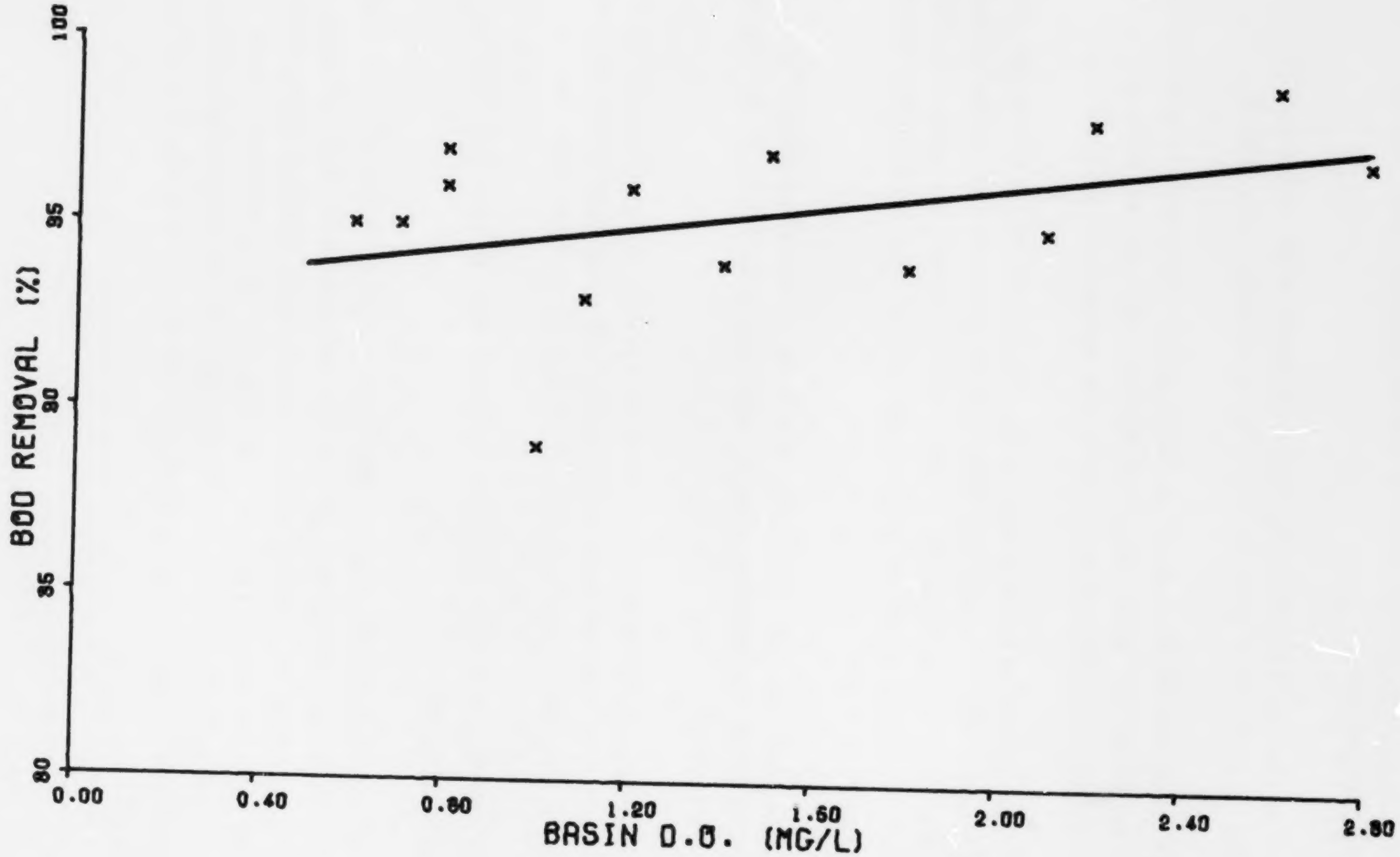


FIGURE 54

AVERAGE BOD REMOVAL VS. AVERAGE BASIN D.O.
(SELECTED DATA)

The average aeration basin temperature did not appear to affect BOD removal between 52 and 66 degrees F. (Figure 55).

The BOD removal seemed to increase with higher pH levels while operating within the range of 7.4 and 8.2 as shown on Figure 56. This may have been a coincidence.

Figures 57 and 58 show that BOD removal increased only a slight amount with increases in influent total phosphate to BOD and total Kjeldahl nitrogen to BOD ratios. This indicates that the treatment system was not significantly deficient in nutrients.

The average substrate removal did not appear to be affected by dissolved oxygen over a wide range of 0.7 to 5.1 mg/l (Figure 59). Higher BOD removals with higher dissolved oxygen levels (Figure 54), while substrate removal stayed about the same, suggest the formation of a better settling sludge at higher dissolved oxygen levels and subsequent better final clarification.

Average basin temperature did not measurably affect the substrate removal (Figure 60); however, substrate removal did increase slightly with pH (Figure 61) as did the BOD removal shown on Figure 56.

The influent total phosphate to BOD ratio and total Kjeldahl nitrogen to BOD ratio did not affect the substrate removal (Figures 62 and 63), indicating that sufficient nitrogen and phosphates were available. These two plots are based on available daily data.

The average BOD:N:PO_4 ratio of the plant influent was 100:6.2:1.1. This ratio is generally considered adequate.

HEAT LOSS RELATIONSHIPS–Figure 64 shows plant influent and effluent temperatures. The difference in the two plots is the heat loss throughout the plant. This net heat loss can be analyzed by plotting the heat lost from the aeration basins versus the heat added to the aeration basins. The heat lost from the basins has been reported [13] to be related to the surface area of the basins and to the temperature differential between the basin contents and the surrounding air. This relationship can be expressed by the following equation:

$$H_L = h_L (T_W - T_A) A$$

where: H_L = heat lost from aeration basins
h_L = heat loss coefficient
T_W = temperature of aeration basin liquor, degrees F
T_A = air temperature, degrees F
A = aeration basin surface area, square feet

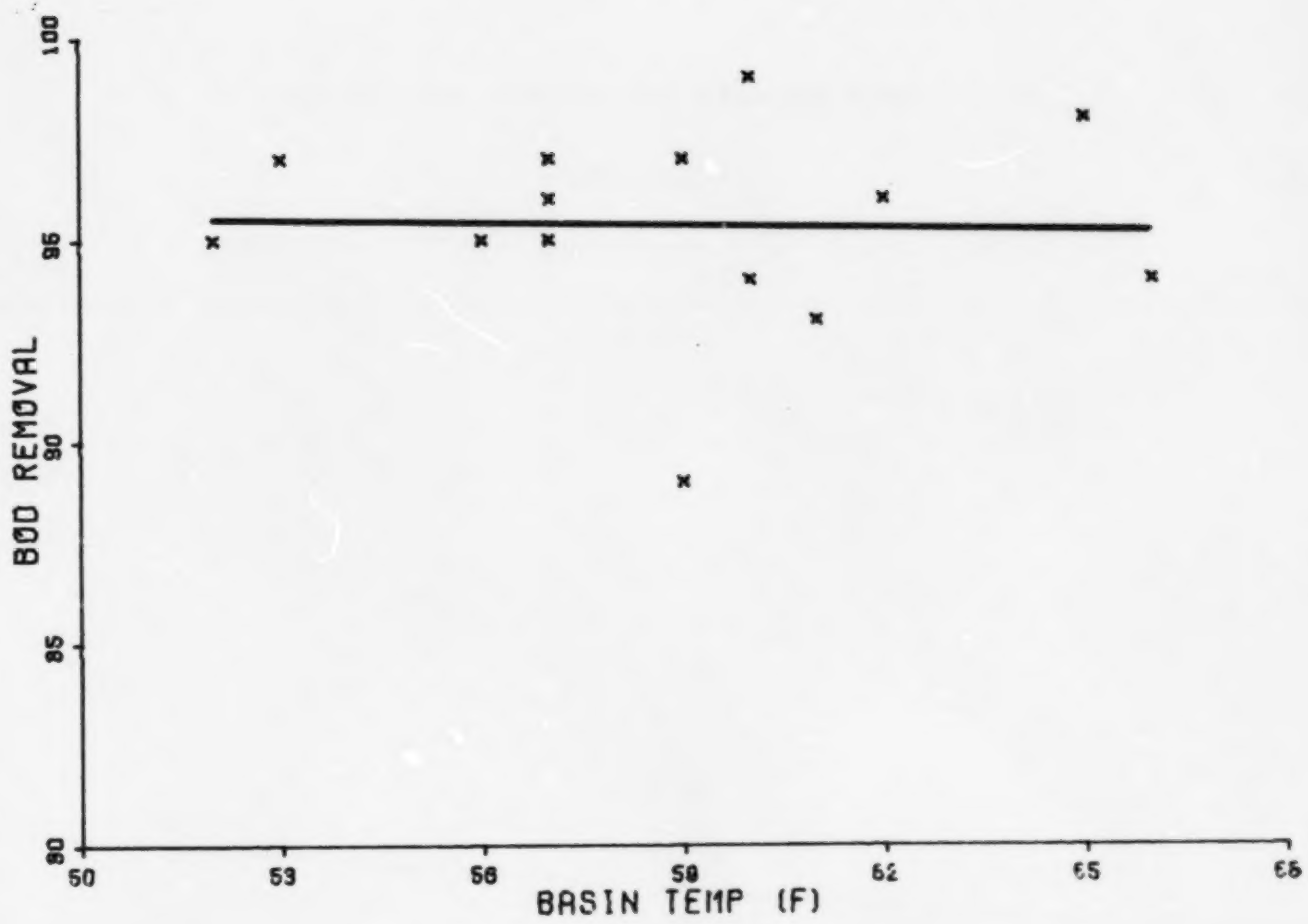


FIGURE 55

AVERAGE BOD REMOVAL VS. AVERAGE BASIN TEMP.
(SELECTED DATA)

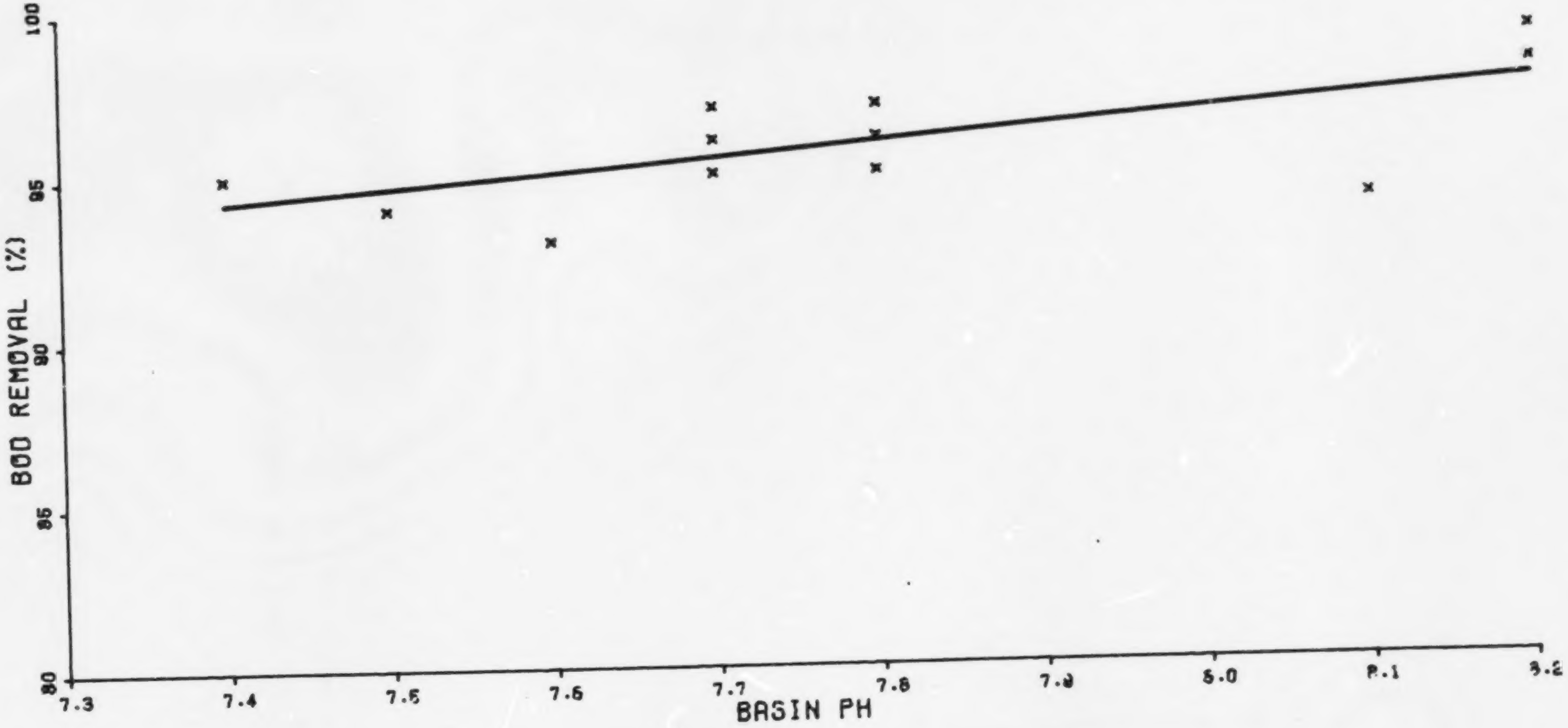


FIGURE 56

AVERAGE BOD REMOVAL VS. AVERAGE BASIN pH

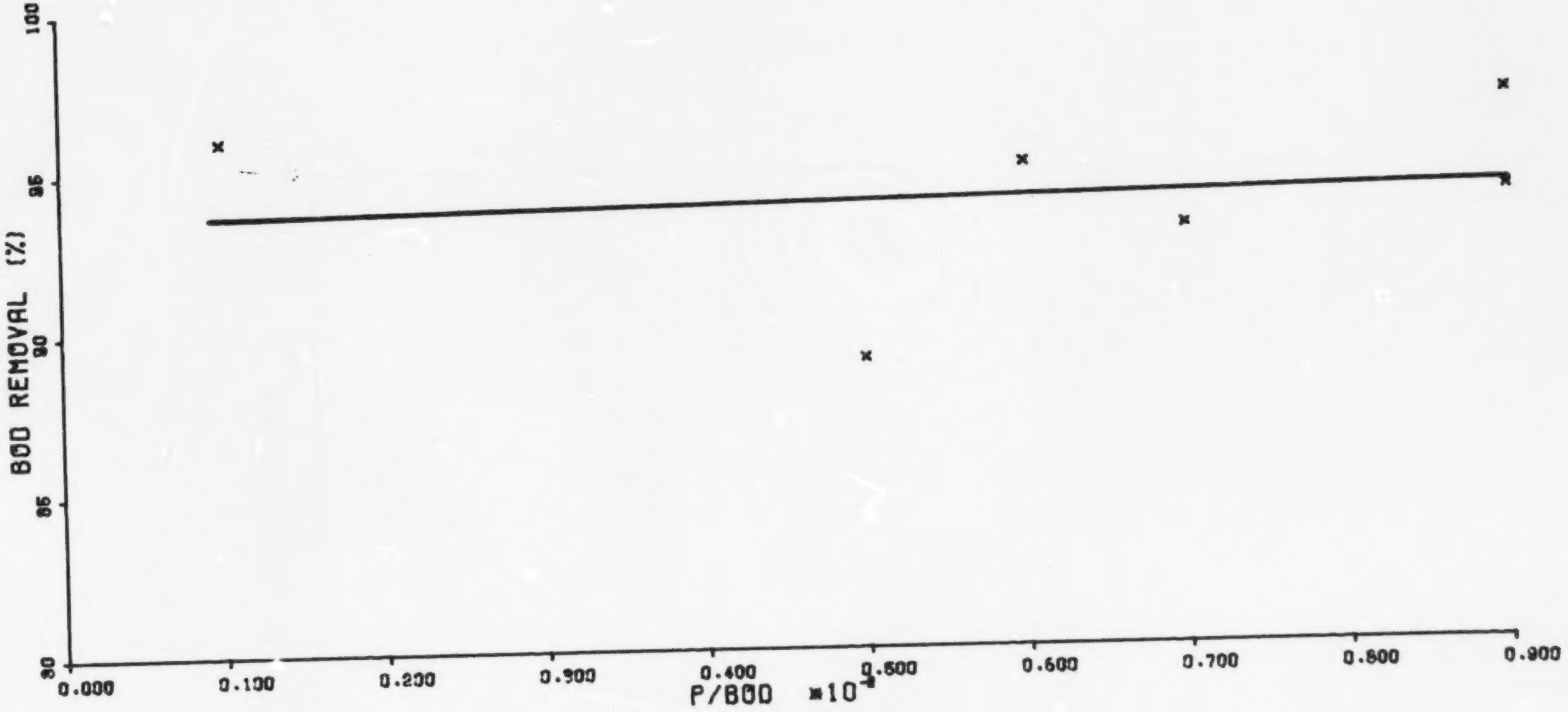


FIGURE 57

AVERAGE BOD REMOVAL VS. AVERAGE PO_4/BOD
(SELECTED DATA)

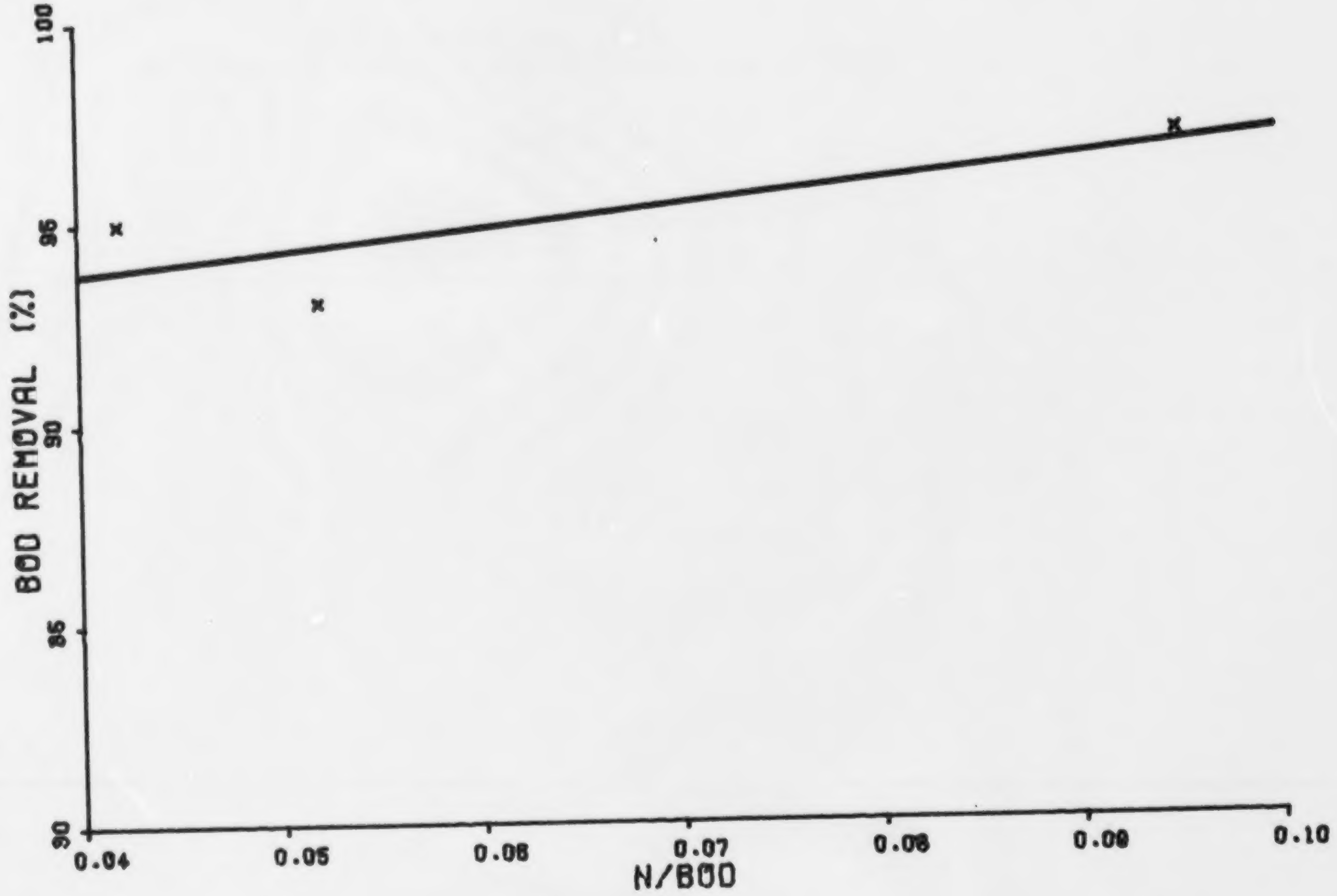


FIGURE 58

AVERAGE BOD REMOVAL VS. AVERAGE N/BOD
(SELECTED DATA)

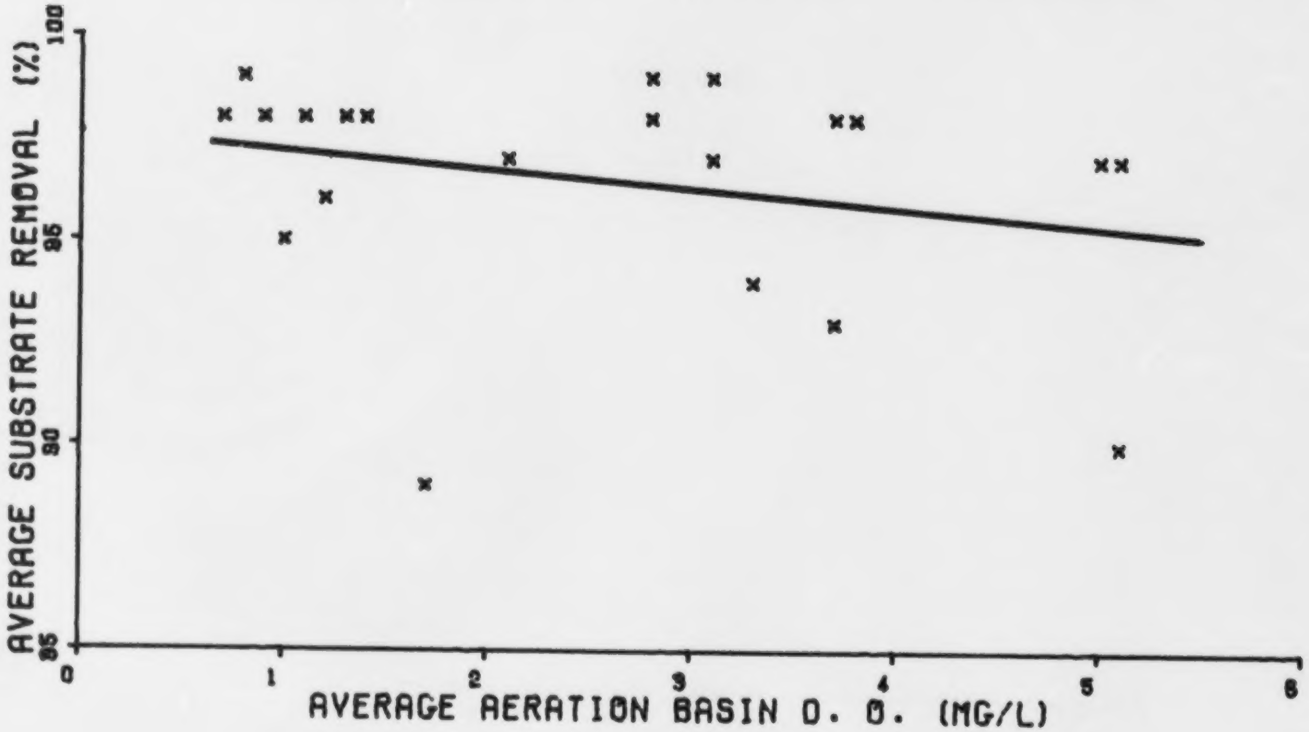


FIGURE 59

AVERAGE SUBSTRATE REMOVAL VS. AVERAGE D.O.
(ALL DATA)

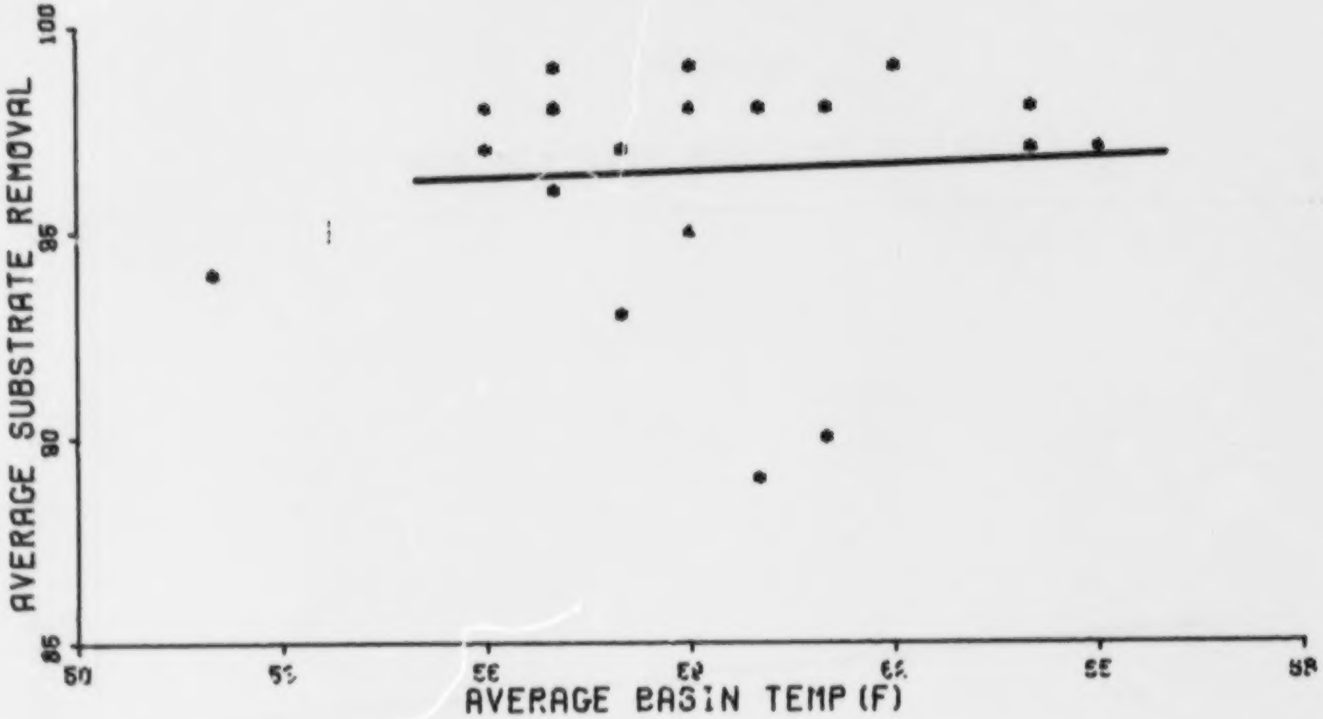


FIGURE 60

AVERAGE SUBSTRATE REMOVAL VS. AVERAGE BASIN TEMP.
(ALL DATA)

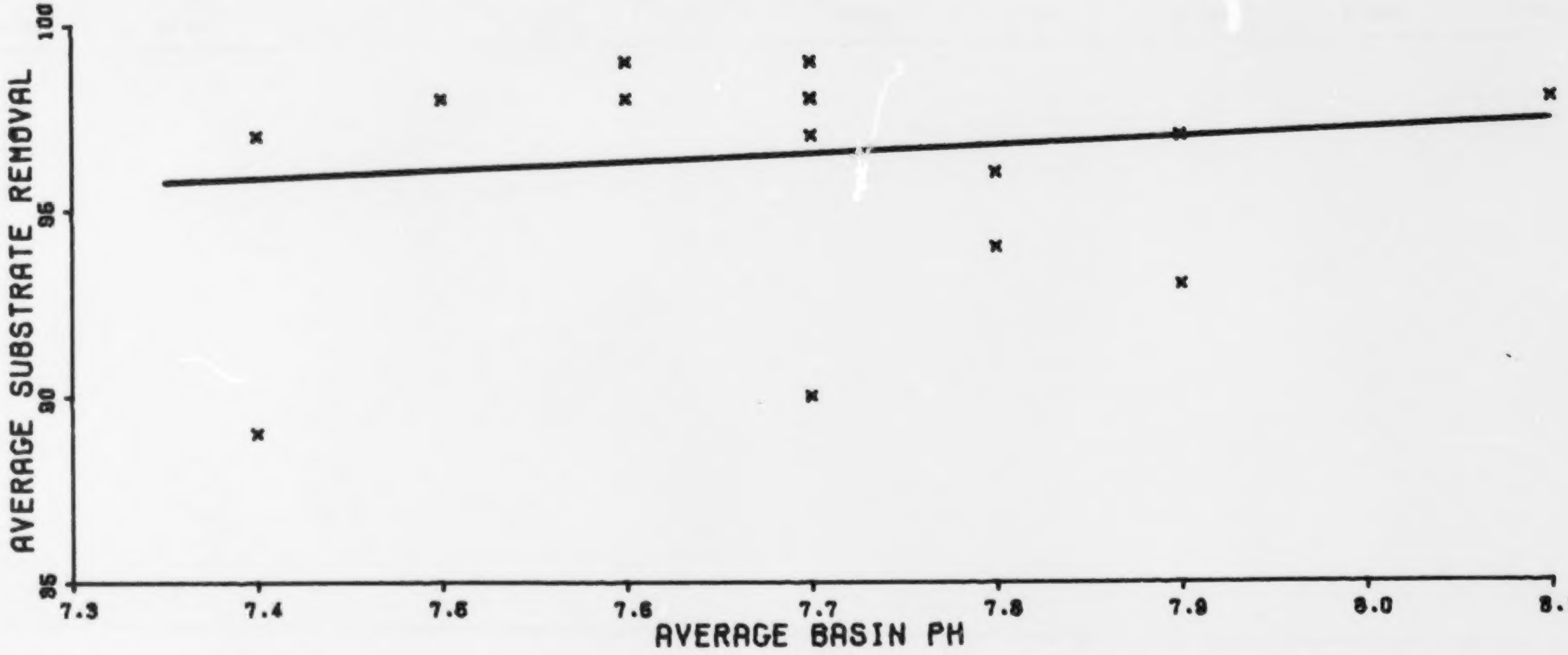


FIGURE 61

AVERAGE SUBSTRATE REMOVAL VS. AVERAGE pH
(ALL DATA)

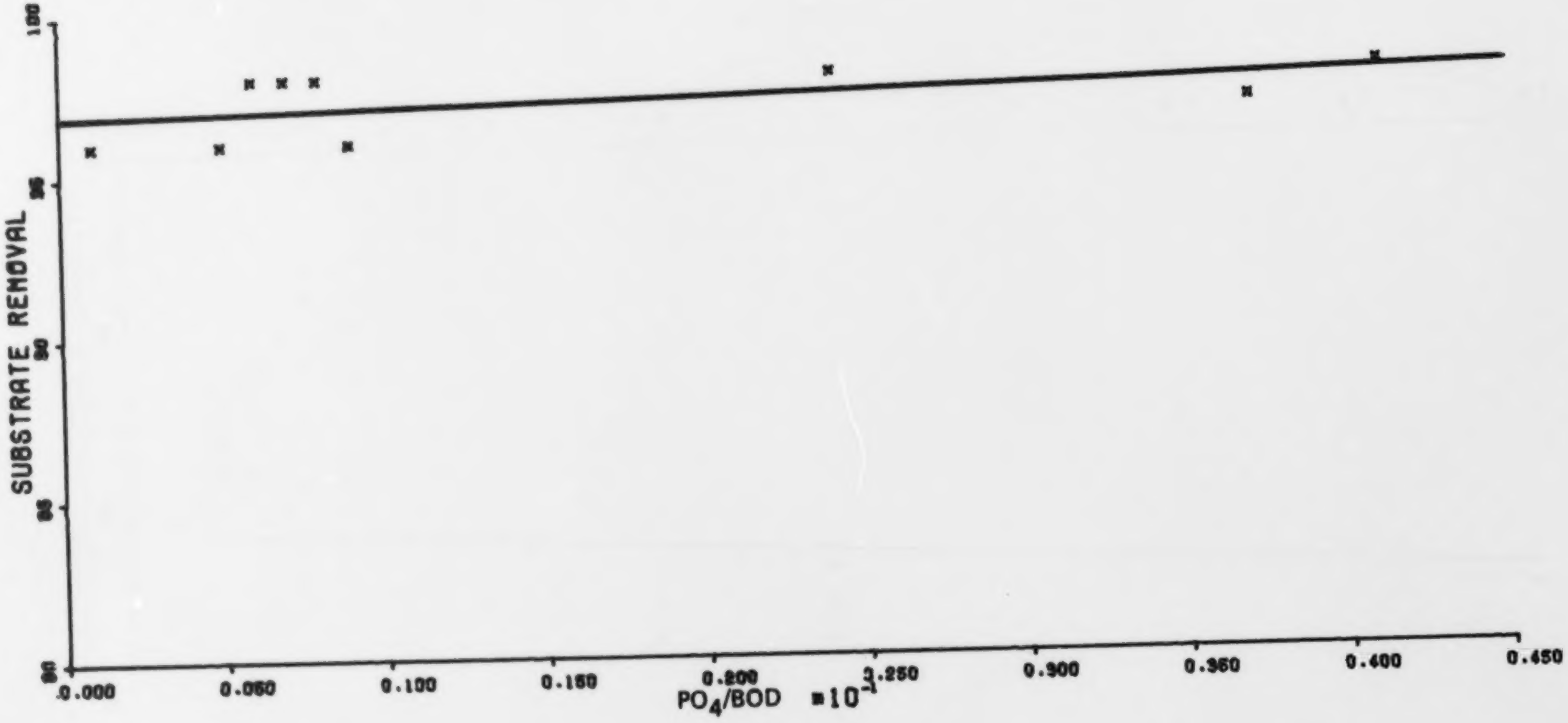


FIGURE 62

SUBSTRATE REMOVAL VS. PO$_4$/BOD

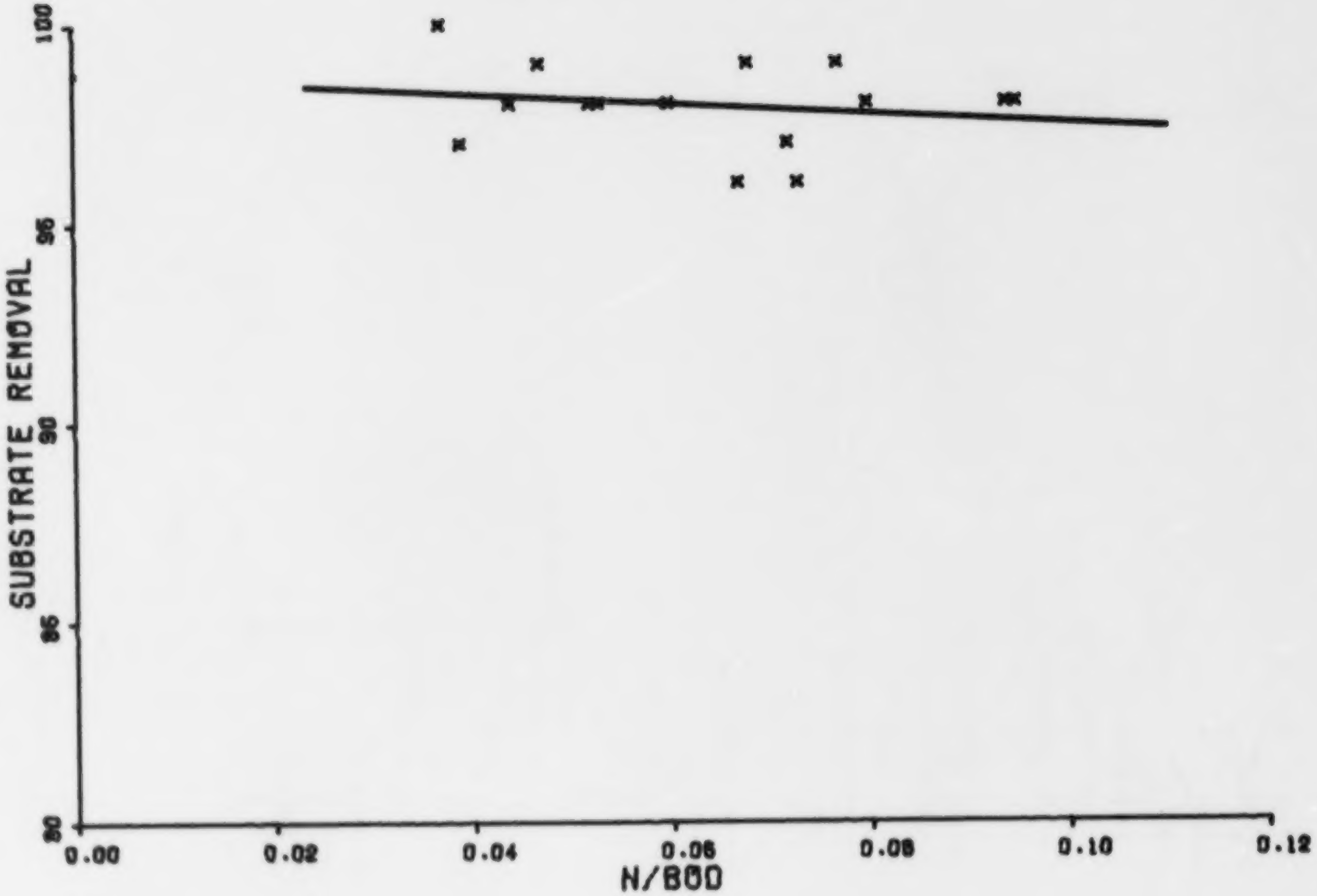


FIGURE 63

SUBSTRATE REMOVAL VS. N/BOD
(ALL DATA)

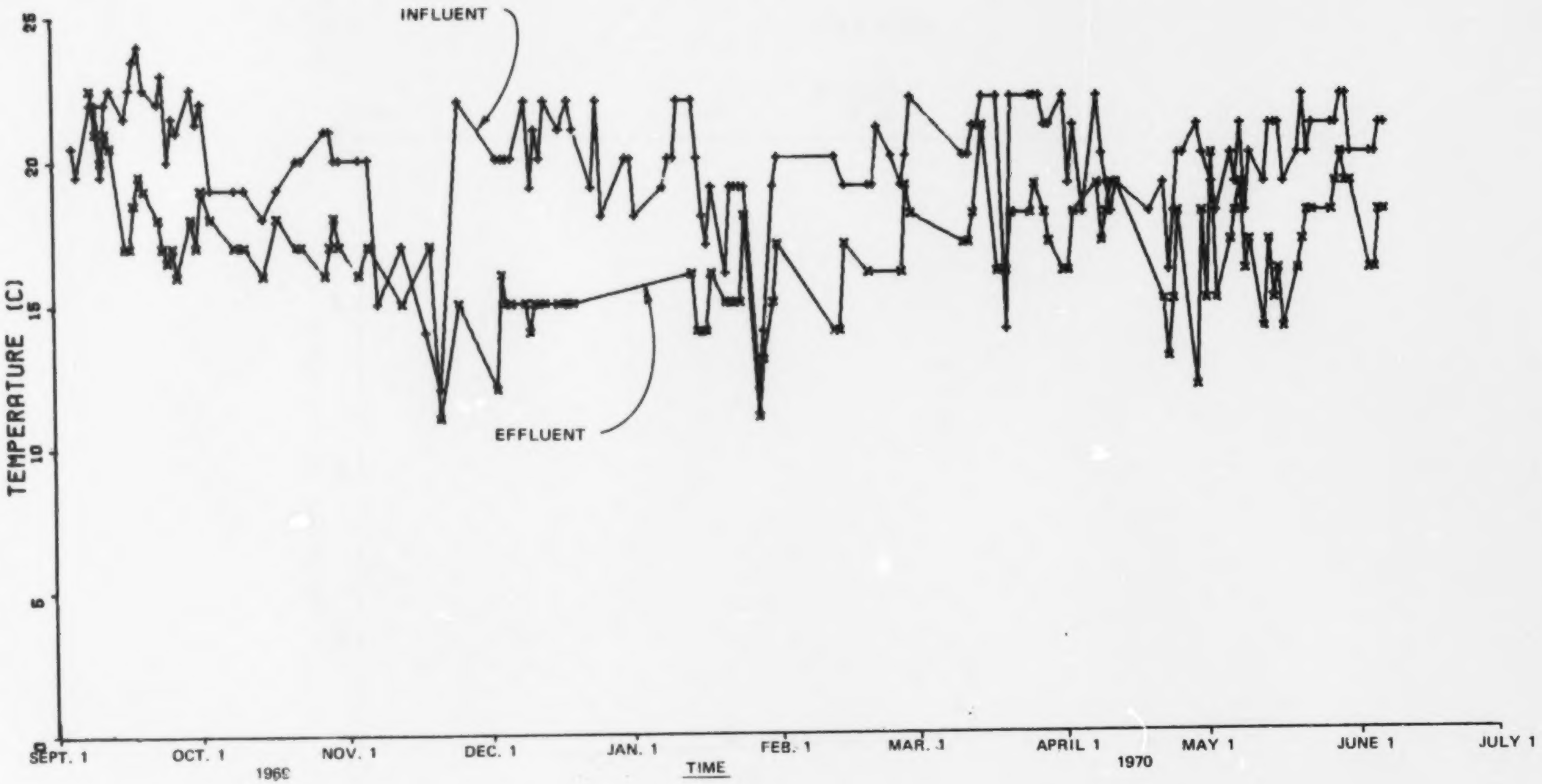


FIGURE 64

PLANT INFLUENT AND EFFLUENT TEMPERATURES
(ALL DATA)

The heat added to the aeration basins has been reported [13] to be related to the influent flow volume and to the temperature differential between the influent flow and the basin contents. This relationship can be expressed with the equation:

$$H_I = h_I (T_I - T_W) Q$$

where:
H_I = heat added to aeration basins
h_I = heat addition coefficient
T_I = temperature of aeration basin influent, degrees F
T_W = temperature of aeration basin liquor, degrees F
Q = aeration basin influent flow, mgd

Assuming that the heat lost from the basins is equal to the heat added to them, the following equations result:

$$H_L = H_I$$

$$h_L (T_W - T_A) A = h_I (T_I - T_W) Q$$

$$h = \frac{h_L}{h_I} = \frac{(T_I - T_W) Q}{(T_W - T_A) A}$$

The heat loss coefficient, h, is directly related to the heat added to the aeration basins and inversely related to the heat lost from the basins. Therefore, as the heat loss increases (with other variables remaining the same), the heat loss coefficient decreases.

Plotting $(T_W - T_A) A$ versus $(T_I - T_W) Q$ will provide a straight line with a slope equal to h. Figures 65 and 66 are similar plots in accordance with the above discussion for two detention times at one hp per million gallon ratio. The lines were passed through (0,0) and the mean coordinates of daily data. The effect of detention time is shown by the lower heat loss coefficient, h, and higher aeration basin heat loss with a longer detention time. Similar plots at higher hp per million gallon ratios are located in Appendix H. The water surface areas of Basin 1 and Basin 2 are 17,850 square feet and 30,370 square feet, respectively, at design water level. The air temperatures used are averages of the maximum and minimum daily temperatures and the influent and basin temperatures are actual average temperatures.

The slopes of the straight lines shown on the figures mentioned above are plotted versus average aeration basin detention times on Figure 67. The hp per million gallon ratios are shown for each point. A general curve is shown passing through the data points and is assumed to be asymptotic at each axis. h is shown to decrease with longer detention

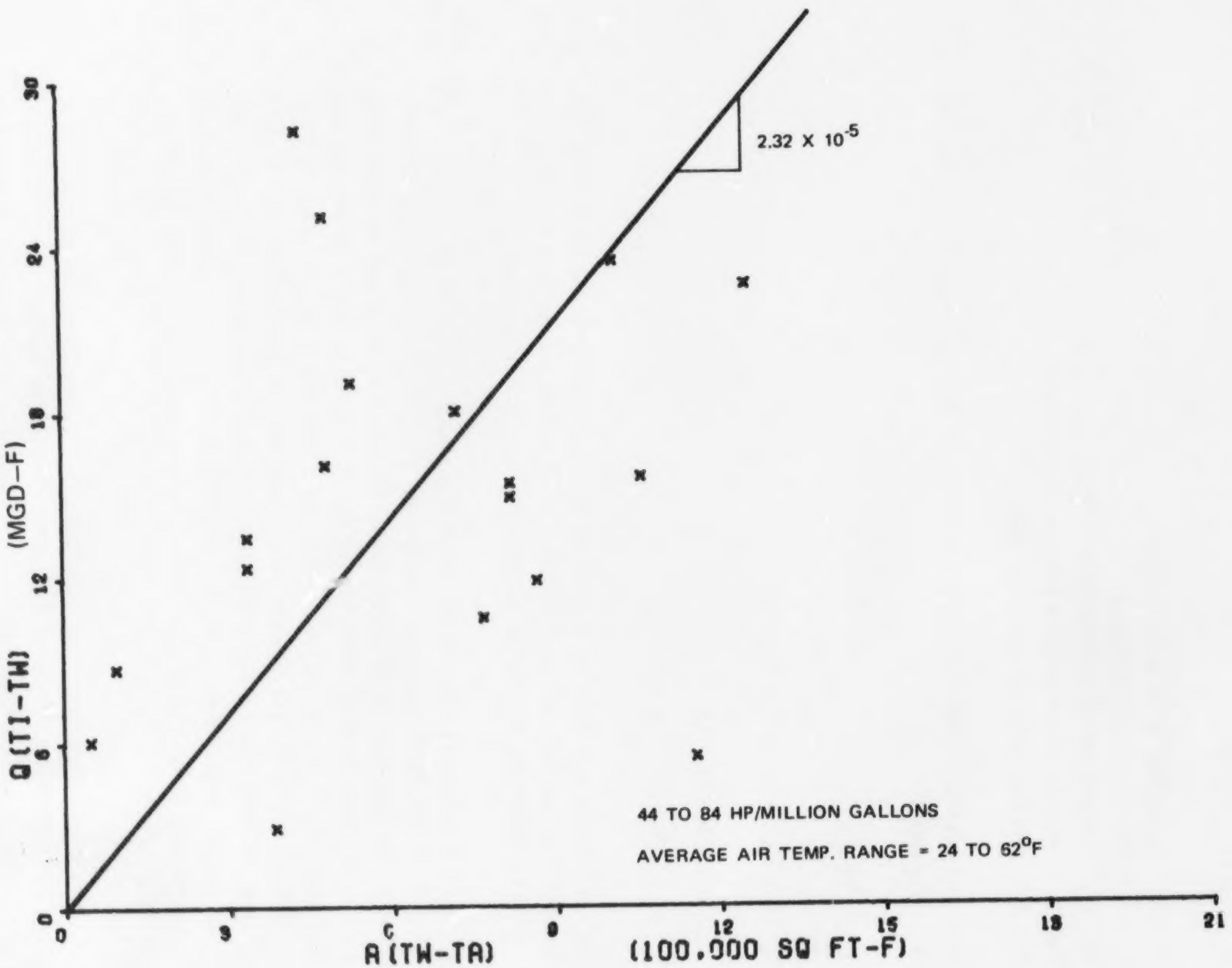
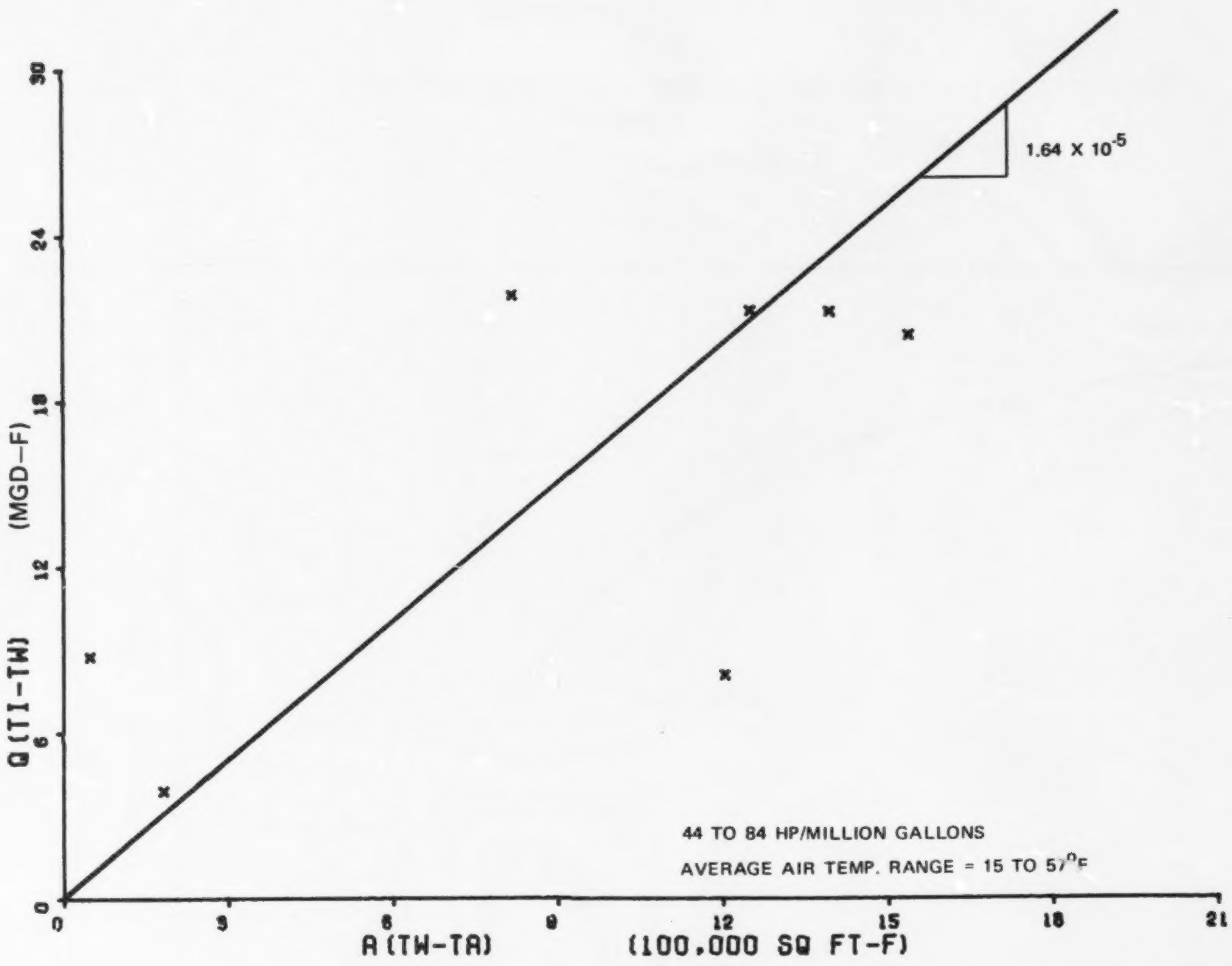


FIGURE 65

AERATION BASIN HEAT LOSS RELATIONSHIP
2 TO 3.5 DAYS DETENTION TIME



44 TO 84 HP/MILLION GALLONS

AVERAGE AIR TEMP. RANGE = 15 TO 57°F

FIGURE 66

AERATION BASIN HEAT LOSS RELATIONSHIP
3.5 TO 6.5 DAYS DETENTION TIME

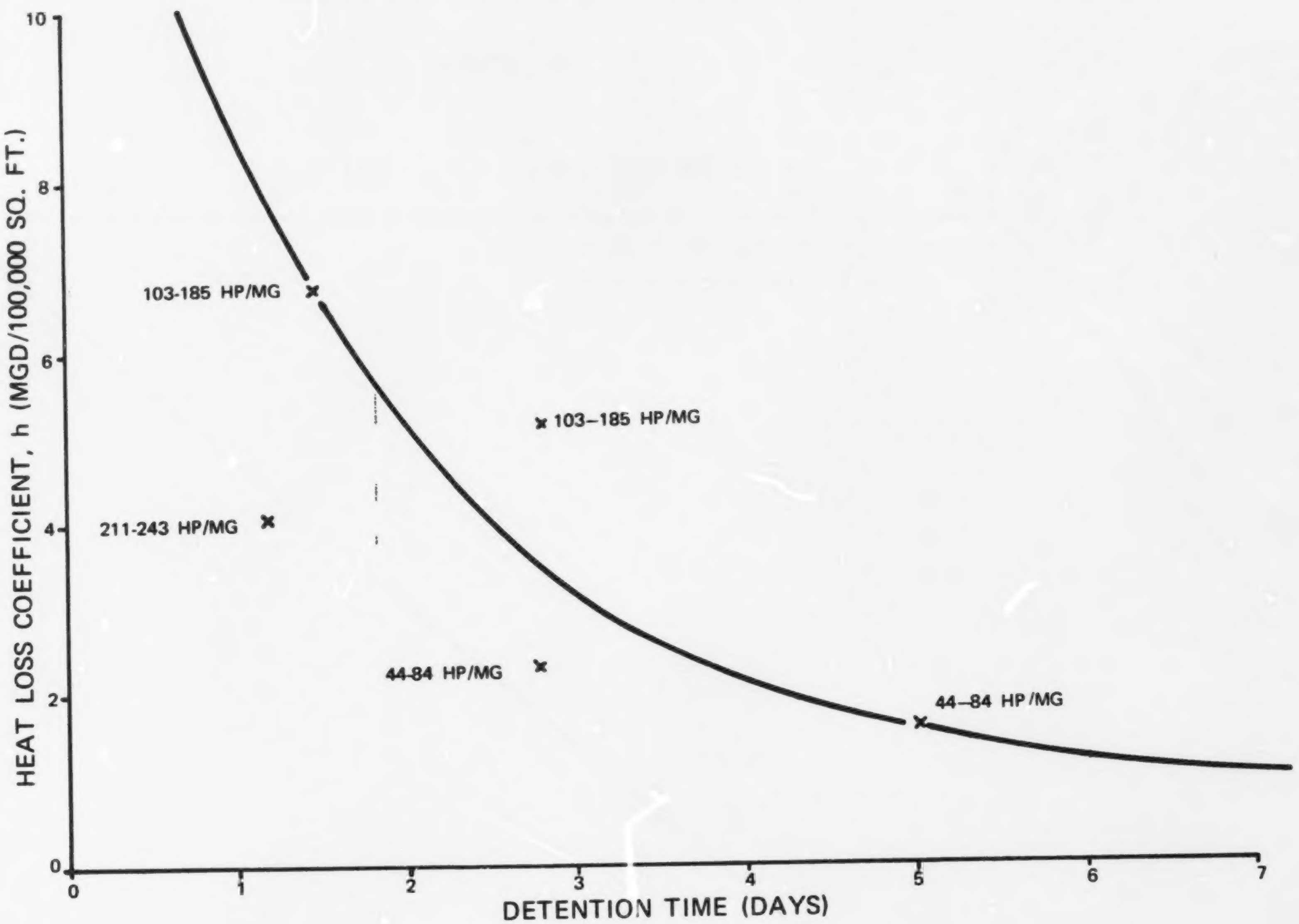


FIGURE 67

AERATION BASIN HEAT LOSS COEFFICIENT VS. DETENTION TIME times. The temperature differential between the basin liquor and the air appears to have a stronger effect on h than the hp per million gallon ratio. This is shown by the lower values of h at 44 to 84 hp per million gallons (with high temperature differentials) than at 103 to 185 hp per million gallons with low temperature differentials.

Figure 67 can be used for design purposes to determine approximate h values for design detention times. The equation for h, which was presented above, can then be solved for the basin liquor temperature, T_W. Additional work should be performed to obtain a clearer understanding of the effects of hp per million gallon ratios and other variables not considered during this project, including the effect of heat loss through the sides and bottom of a basin, the effect of wind velocity, and the effect of solar radiation.

SECONDARY CLARIFIER LOADING–Section VII includes secondary clarifier operational data, which show that effluent suspended solids and BOD values are somewhat related to clarifier loading, which, in turn, is dependent upon the MLSS and the flow rate to the clarifier. The ability of the clarifier to settle and compact the solids applied to it is a function of the SVI of the MLSS, as well as the solids loading. The higher the SVI value is, the lower the settleability of the mixed liquor. When the SVI increases to a point of clarifier overload, the MLSS load must be decreased in compensation, by increasing the rate of sludge wasting.

Figure 68 is a plot of MLSS versus (Q + RQ)SVI, using different symbols for good and poor operation. Q represents total plant influent and R is the quantity of return sludge as a fraction of total plant influent. A straight line is drawn between the good data and poor data. Good secondary clarification can be predicted by operating the system so that the coordinates of (Q + RQ)SVI and MLSS fall below the line. Acceptable operation allows lower (Q + RQ)SVI values for increased MLSS levels.

SOLIDS TREATMENT AND DISPOSAL

WASTE ACTIVATED SLUDGE CHARACTERISTICS–A sample of waste activated sludge was concentrated, analyzed, and found to contain and exhibit the following listed materials and characteristics:

pH	6.6
Moisture	94.5%
Protein	1.9%
Fat	0.02%
Fiber	0.16%
Ash	1.64%
NFE (Nitrogen Free Extract)	1.78%
TDN (Total Digestible Nutrients)	2.7%

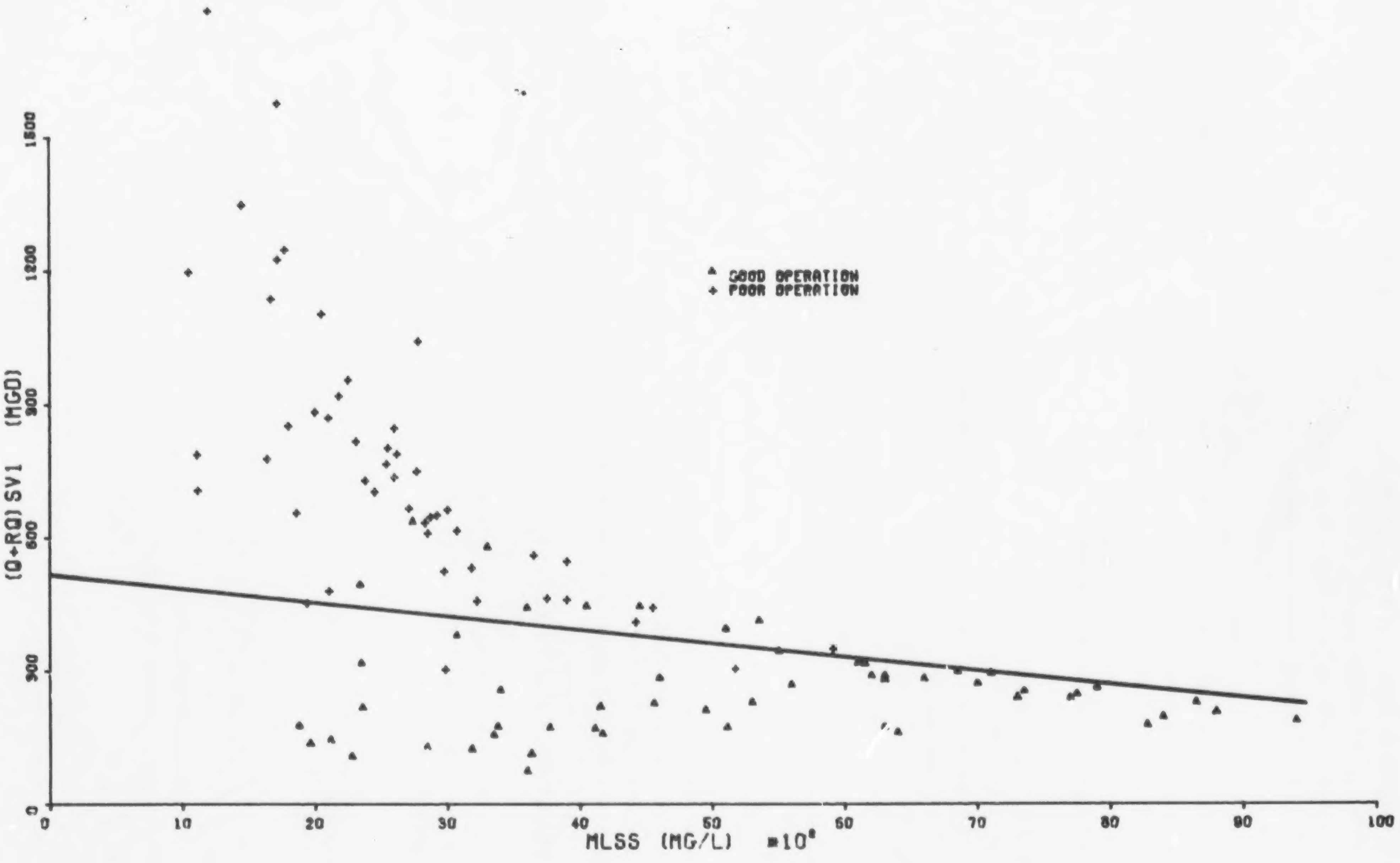


FIGURE 68

SECONDARY CLARIFIER LOADING FACTOR VS. MLSS
(ALL DATA)

Calcium	0.25%
Phosphorus	0.051%
Iron	0.0028%
Sodium	0.099%
Pesticides	None Detected

A laboratory report on this analysis is located in Appendix F.

The protein content of the waste activated sludge amounted to 34.5 percent of the total solids, indicating that it may have a nutrition value high enough to allow use in animal feed.

The heat value, or calorific value, of the waste activated sludge was found to be 5,200 Btu per pound of total solids or 9,020 Btu per pound of volatile solids. The volatile solids value is about 10 percent below values reported for dairy waste sludge, pulp and paper waste sludge, and domestic sewage activated sludge [12].

TREATMENT SYSTEM SOLIDS–The variation of the average VSS to TSS ratio through the treatment system is listed below:

Location	VSS/TSS
Plant Influent	0.70
Aeration Basins	0.70
Final Effluent	0.52
Return Sludge	0.74
Waste Sludge	0.74

The BOD to VSS ratio of the plant influent solids was 0.49, while the same ratio for the plant effluent solids was 0.55 and did not appear to be dependent on sludge age.

SECTION XII
ACKNOWLEDGMENT

This project was supported in part by Research and Development Grant WPRD 15-01-68, Program 12060 EHV, from the Environmental Protection Agency.

SECTION XIII
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SECTION XIV
APPENDIXES

APPENDIX A

APPENDIX A
GLOSSARY

Some of the various terms frequently used in conjunction with wastewater systems and referred to throughout this report are defined as follows:

ACCLIMATION–Period during which the microorganisms become accustomed to their new environment and substrate.

ACTIVATED SLUDGE–A biological mass produced in wastewater by the growth of bacteria and other microorganisms in the presence of dissolved oxygen, and accumulated in sufficient concentration by returning floc previously formed.

ACTIVATED SLUDGE PROCESS–A method of secondary wastewater treatment in which a mixture of wastewater and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation, and wasted or returned to the process as needed.

AERATION–The bringing about of intimate contact between air and liquid by one of the following methods: spraying the liquid in the air, bubbling air through the liquid, or agitation of the liquid to promote surface absorption of air.

AERATOR–A device which agitates the liquid and brings fresh surfaces of liquid into contact with the atmosphere, thereby introducing atmospheric oxygen into the liquid by mechanical means.

AEROBIC TREATMENT–A biological treatment process in which bacteria stabilize organic matter in the presence of dissolved oxygen.

ANAEROBIC TREATMENT–A biological treatment process in which bacteria stabilize organic matter in the absence of dissolved oxygen.

AVERAGE DAILY FLOW–The average quantity of wastewater reaching a given point in a 24-hour period.

BIOCHEMICAL OXYGEN DEMAND (BOD)–A measure of the oxygen necessary to satisfy the requirements for the aerobic decomposition of the decomposable organic matter in a liquid by bacteria. The standard (BOD_5) is five days at 20 degrees C.

BIOLOGICAL SEED–Sludge that has undergone decomposition which is mixed with undecomposed wastewater for the purpose of introducing favorable organisms, thereby accelerating the initial stages of decomposition.

BUFFER–The action of certain solutions in opposing a change of composition, especially of pH.

CHEMICAL OXYGEN DEMAND (COD)–A measure of the oxygen required to approach total oxidation of the organic matter in the waste.

CLARIFIER–A tank or basin, in which wastewater is retained for a sufficient time, and in which the velocity of flow is sufficiently low to remove by gravity a part of the suspended matter.

COAGULANT–A chemical, which, when added to water or wastewater, furnishes ionic charges opposite to those of the colloidal turbidity particles in the water or wastewater, allowing the colloidal particles to come together in the form of a flocculant precipitate.

COAGULATION–The agglomeration of colloidal or finely divided suspended matter in water or wastewater by the addition of an appropriate coagulant.

COMPLETELY MIXED ACTIVATED SLUDGE–Treatment system in which the untreated wastewater is instantly mixed throughout the entire aeration basin.

COMPOSITE SAMPLE–Integrated sample collected by taking a portion at regular time intervals, with sample size varying with flow; or taking uniform portions on a time schedule varying with the total flow.

DETENTION TIME–Period of time required for a liquid to flow through a tank or unit.

DISSOLVED OXYGEN (DO)–Free or uncombined oxygen in a liquid.

EFFLUENT–Liquid flowing out of a basin or treatment plant.

FLOC–Small gelatinous masses, formed in water or wastewater by the addition of coagulants, through biochemcial processes, or by agglomeration.

FLOCCULATION–The bringing together of flocculating particles by hydraulic or mechanical means.

INDUSTRIAL WASTEWATER–Flow of waste liquids from industries using large volumes of water from processing industrial products, such as food processing plants.

INFLUENT–Liquid flowing into a basin or treatment plant.

MILLIGRAMS PER LITER (mg/l)–The weight of material in one liter of liquid.

MIXED LIQUOR (ML)–A mixture of sludge and wastewater in a biological reaction tank undergoing biological degradation in an activated sludge system.

NITRIFICATION–A biological process in which certain groups of bacteria, when in the presence of dissolved oxygen, convert ammonia nitrogen first to nitrites and then to nitrates.

NUTRIENT–Any substance absorbed by organisms which promotes growth and replacement of cellular parts.

OXYGEN UPTAKE RATE–Oxygen utilization rate or rate at which oxygen is used by bacteria in the decomposition of organic matter.

PEAK FLOW–The highest average daily flow occurring throughout a period of time.

pH–The logarithm of the reciprocal of the hydrogen ion concentration. It is used to express the intensity of the acid or alkaline condition of a solution.

POLYELECTROLYTES–High molecular weight water soluble polymers that contain groups capable of undergoing electrolytic dissociation to give highly charged, large molecular weight ions. Polymers whose functional groups in water solution give positively charged ions are cationic, while polymers that dissociate to form negatively charged ions are called anionic. Polymers which dissociate to yield both large positive and large negative ions are referred to as nonionic.

PRIMARY TREATMENT–A wastewater treatment process that utilizes sedimentation and/or flotation to remove a substantial portion of the settleable or flotable solids and accompanying BOD of untreated wastewater.

RETURN SLUDGE–Sludge which has settled in the final clarifier and is returned to the biological reaction tank in an activated sludge system.

SECONDARY TREATMENT–A wastewater treatment process that utilizes microorganisms to reduce the oxygen demand and pollutional load of primary treated wastewater and to remove the solids resulting from the process.

SETTLEABLE SOLIDS–Suspended solids which will settle in sedimentation basins (clarifiers) in normal detention times.

SLUDGE–The accumulated settled solids separated from wastewater in clarifiers, and containing more or less water to form a semi-liquid mass.

SLUDGE AGE–The average total time of detention of a suspended solids particle in a system. It is defined as the total weight of suspended solids in the aeration basin divided by the total weight of suspended solids in the effluent and otherwise wasted per day.

SLUDGE DENSITY INDEX (SDI)–The reciprocal of the sludge volume index (SVI) multiplied by 100.

SLUDGE VOLUME INDEX (SVI)–The volume of sludge occupied by one gram of activated sludge after 30 minutes of quiescent settling in a 1,000 ml graduated cylinder.

SUBSTRATE–Raw waste feed on which a microorganism grows or is placed to grow by decomposing the waste material.

SUBSTRATE REMOVAL–The total BOD in plant influent, minus the soluble BOD in plant effluent, divided by the total influent BOD.

SUPERNATANT LIQUOR–The liquid overlying settled solids.

SUSPENDED SOLIDS (SS or TSS)–The quantity of material deposited when a quantity of wastewater is filtered through an asbestos mat in a Gooch crucible, or equal method.

TOTAL SOLIDS (TS)–The solids in the wastewater, both suspended and dissolved.

VOLATILE SUSPENDED SOLIDS (VSS)–The quantity of suspended solids in wastewater that are lost on ignition of the total suspended solids.

WASTE SLUDGE–Sludge which is no longer needed in the treatment system and therefore is disposed of.

APPENDIX B

APPENDIX B

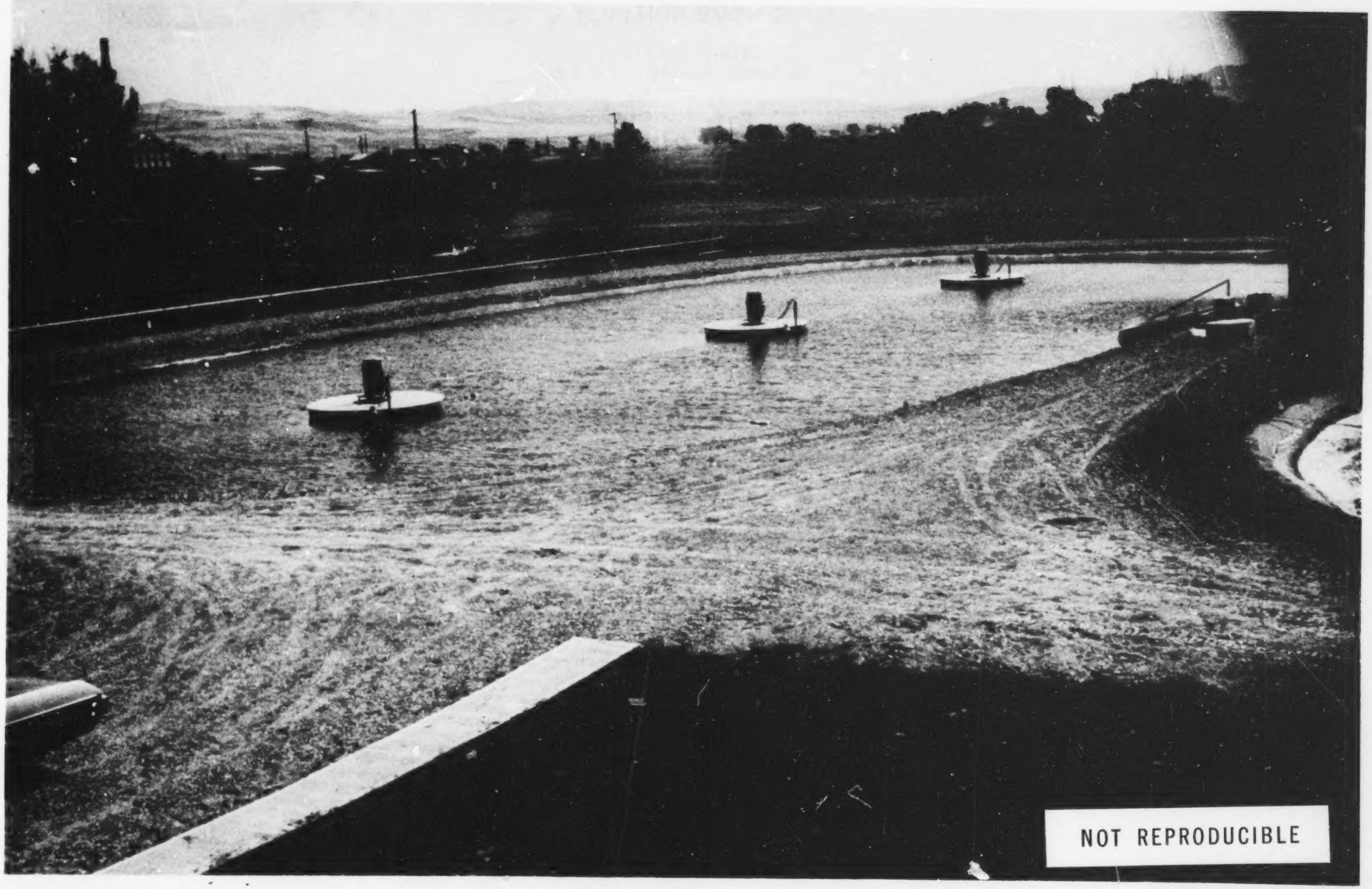
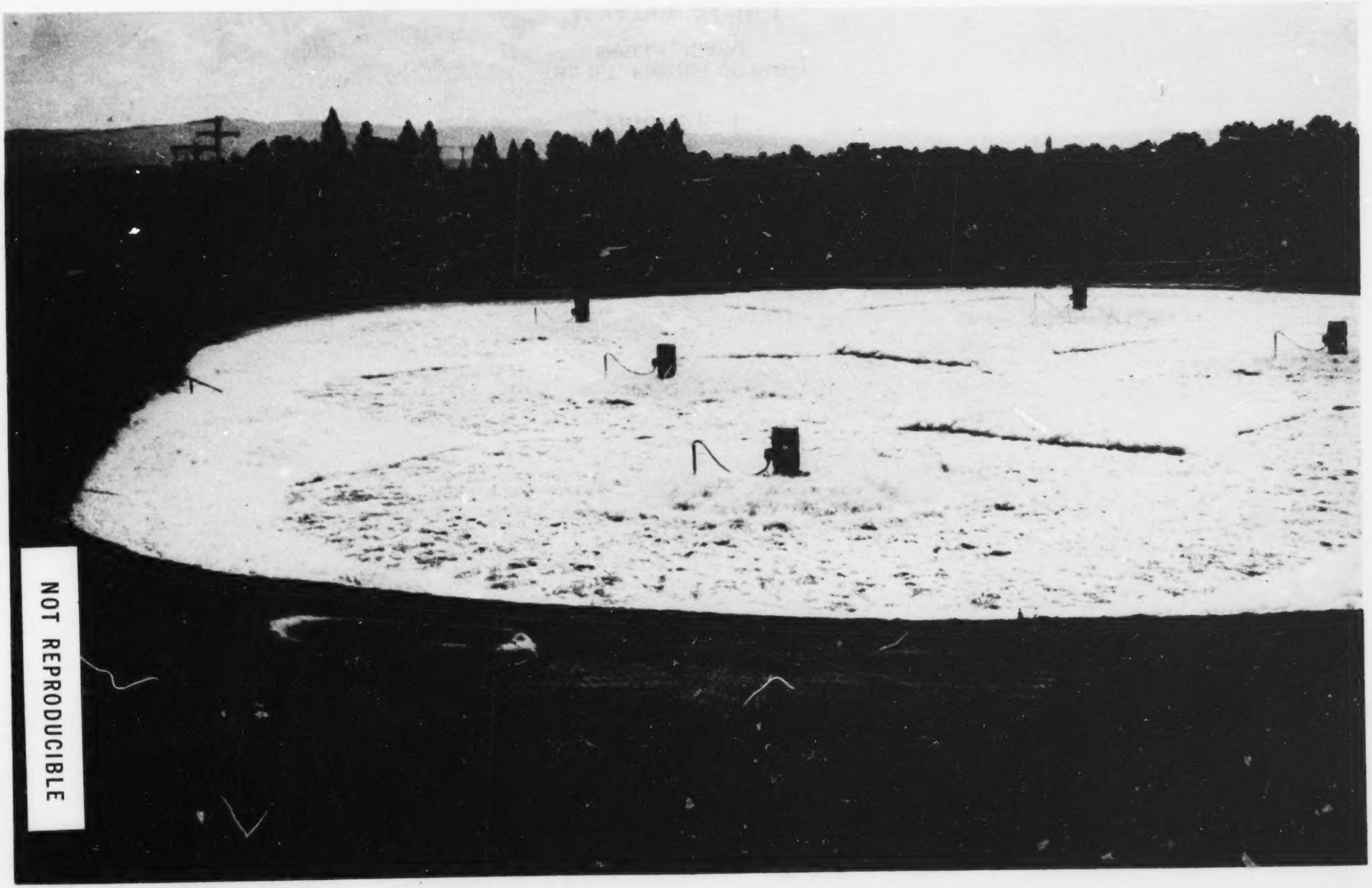

NOT REPRODUCIBLE

FIGURE B–1

THE R.T. FRENCH COMPANY
SHELLY, IDAHO

AERATION BASIN 1

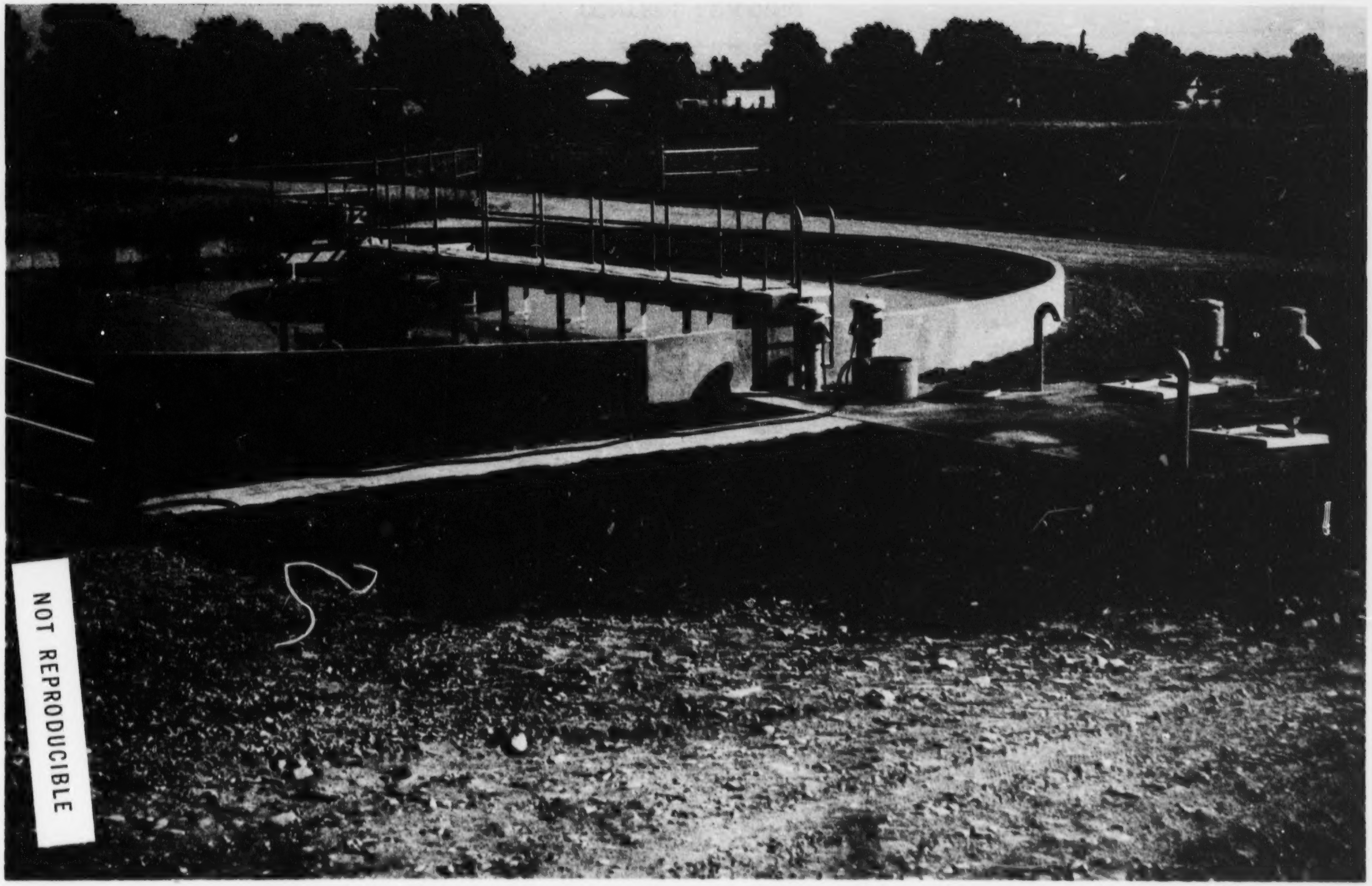


NOT REPRODUCIBLE

FIGURE B–2

THE R.T. FRENCH COMPANY
SHELLEY, IDAHO

AERATION BASIN 2

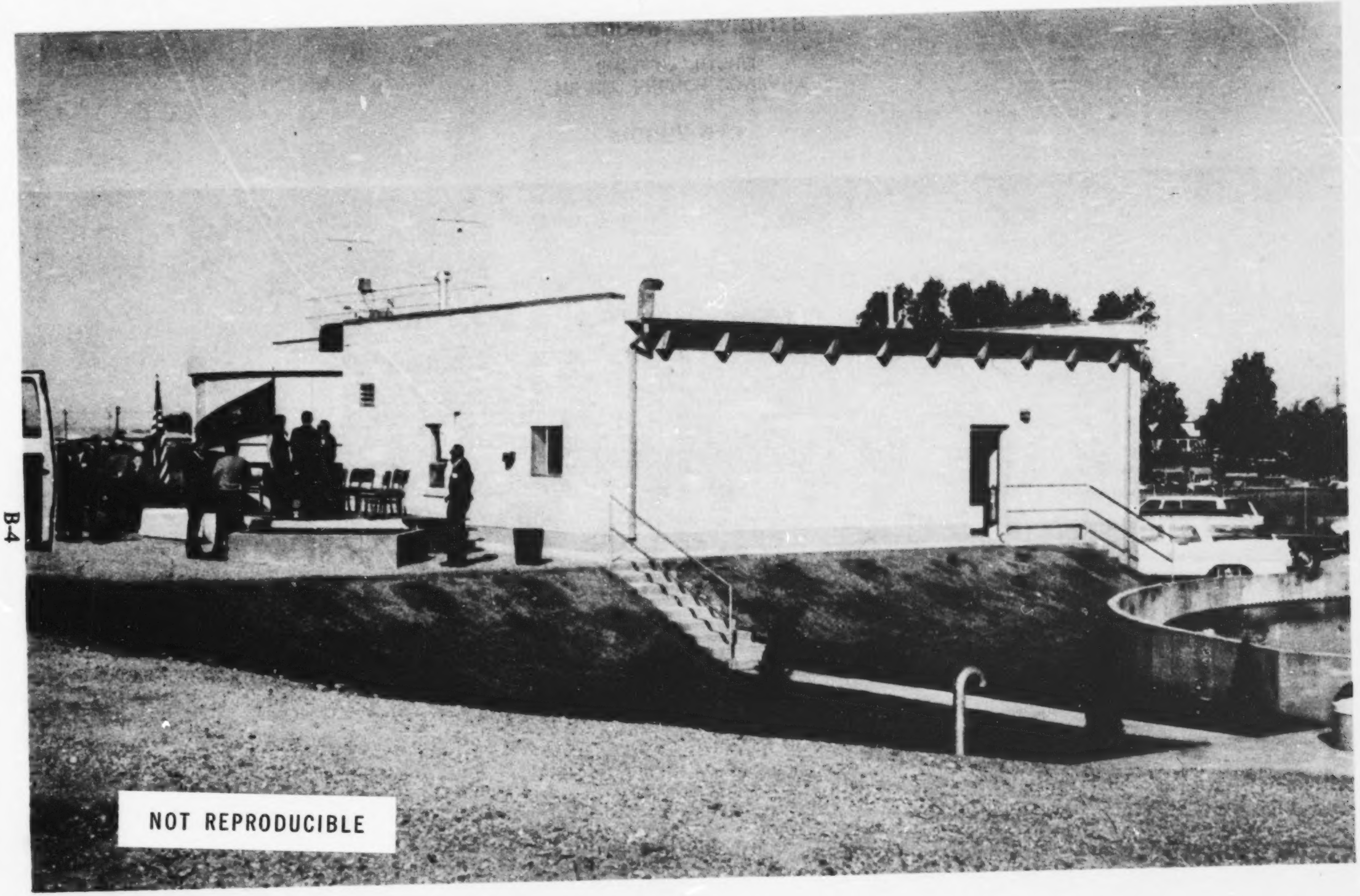


NOT REPRODUCIBLE

FIGURE B–3

THE R.T. FRENCH COMPANY
SHELLEY, IDAHO

SECONDARY CLARIFIER



NOT REPRODUCIBLE

FIGURE B–4

THE R.T. FRENCH COMPANY
SHELLEY, IDAHO

CONTROL BUILDING

NOT REPRODUCIBLE

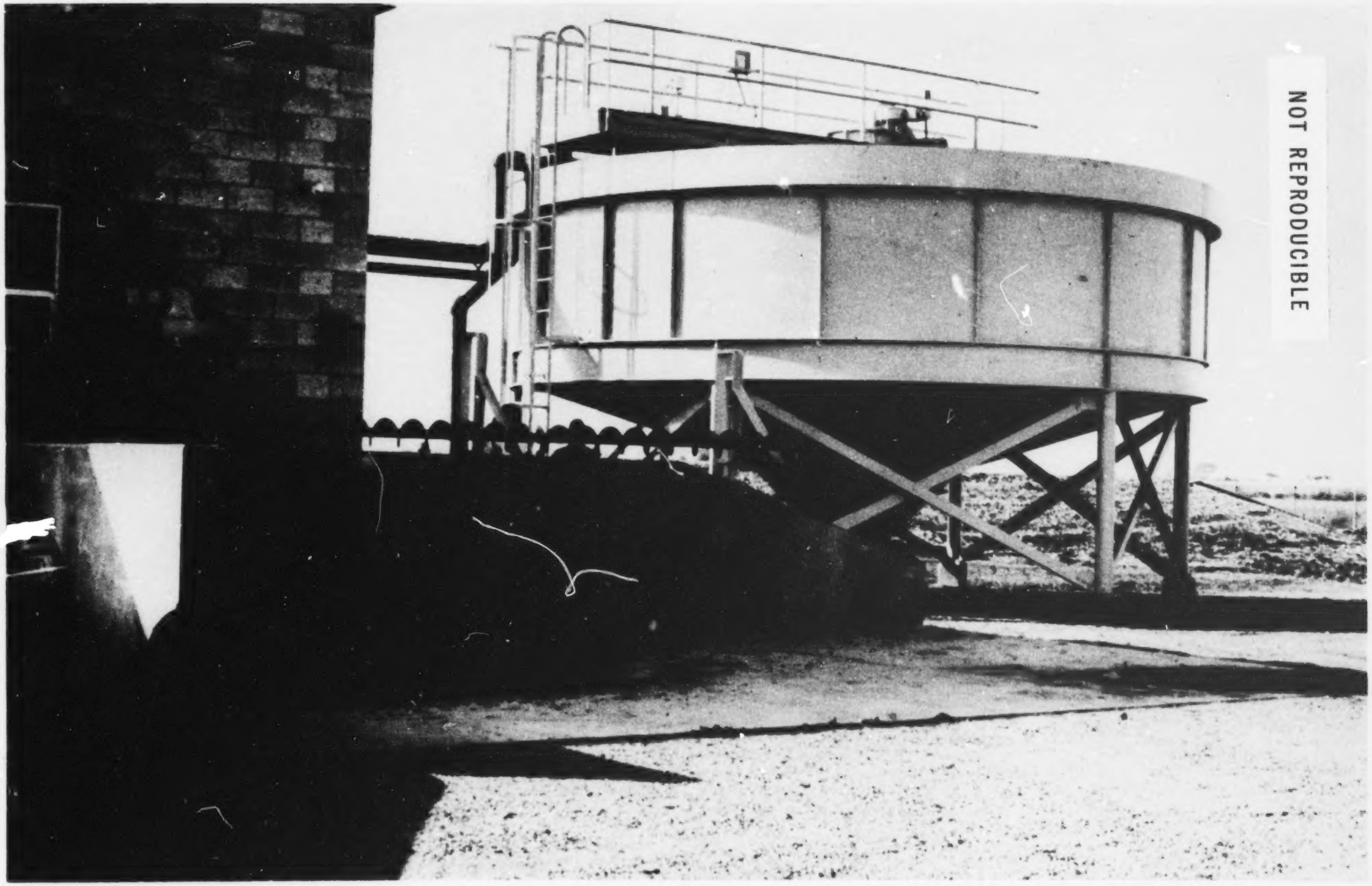


FIGURE B–5

THE R.T. FRENCH COMPANY
SHELLEY, IDAHO

CLARIFIER – THICKENER

APPENDIX C

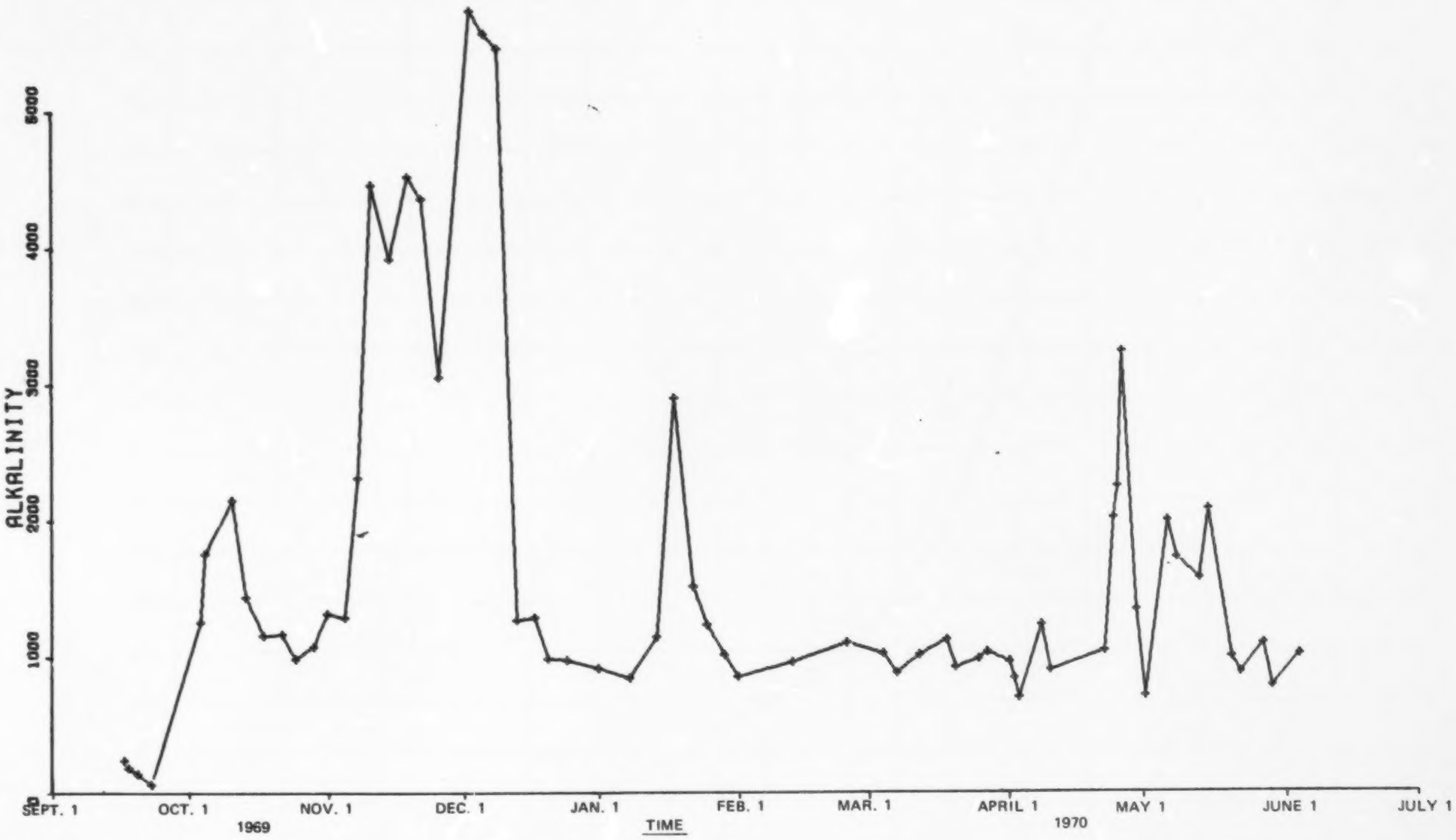


FIGURE C–1

INFLUENT ALKALINITY VS. TIME

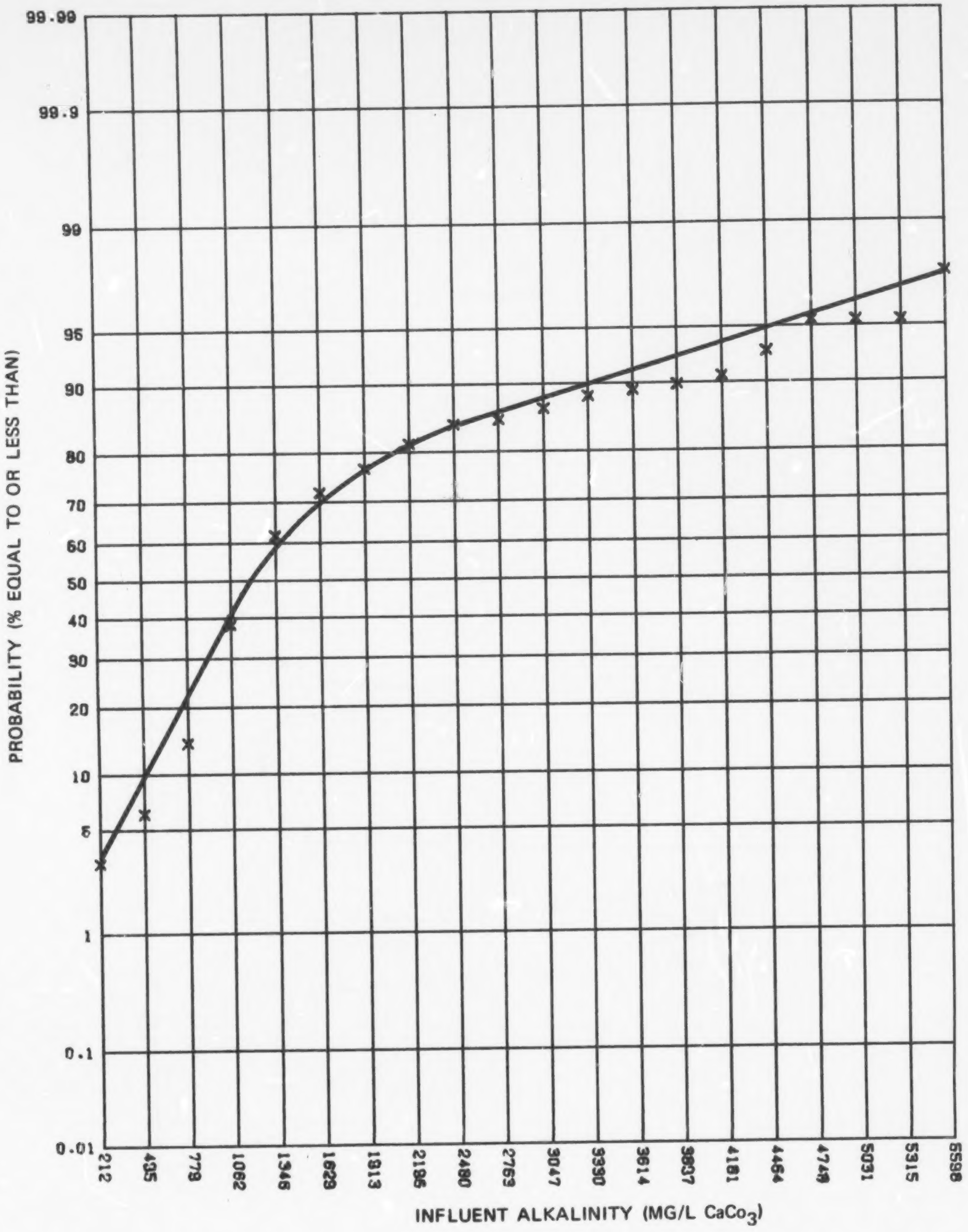


FIGURE C–2

PROBABILITY OF INFLUENT ALKALINITY

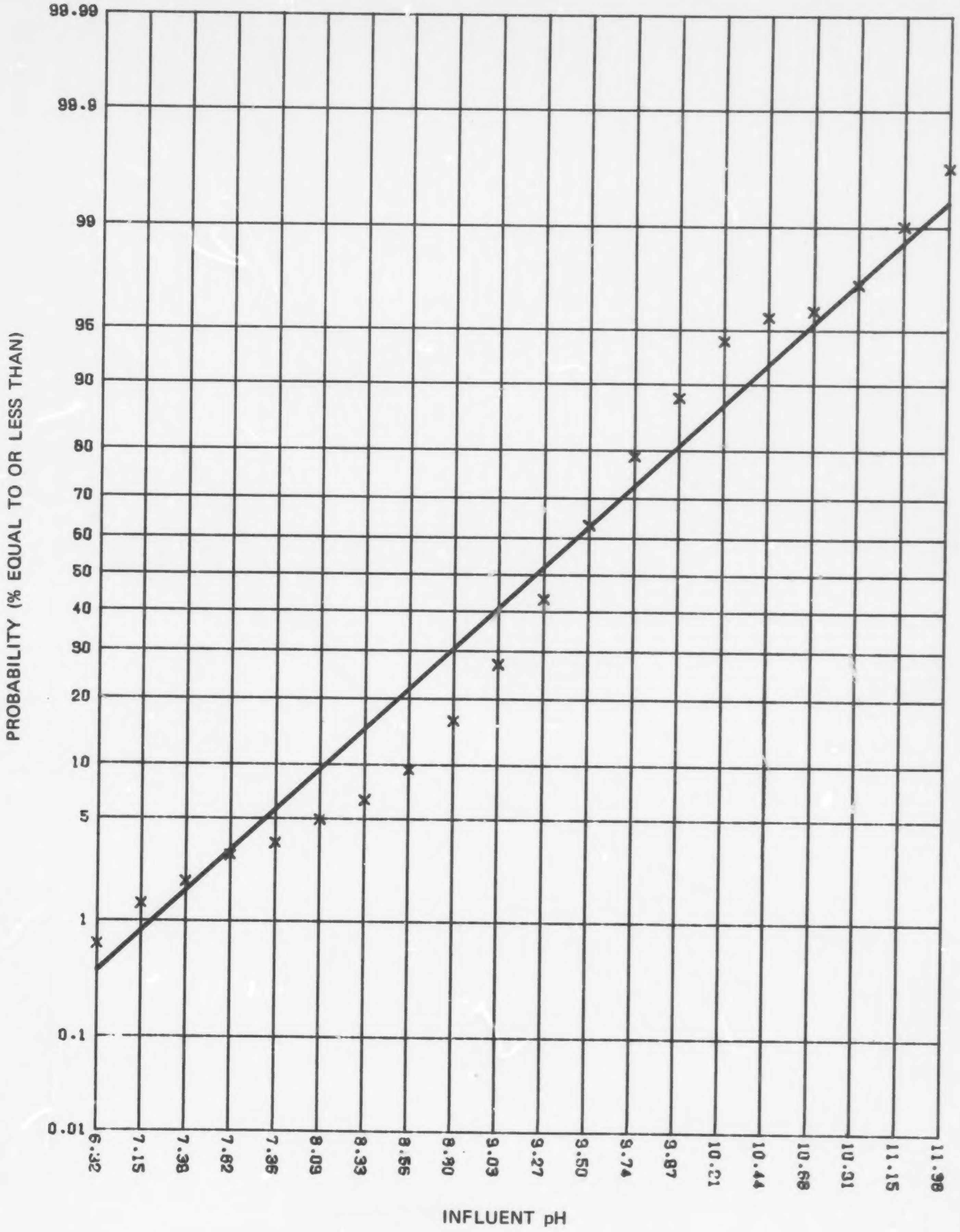


FIGURE C–3

PROBABILITY OF INFLUENT pH

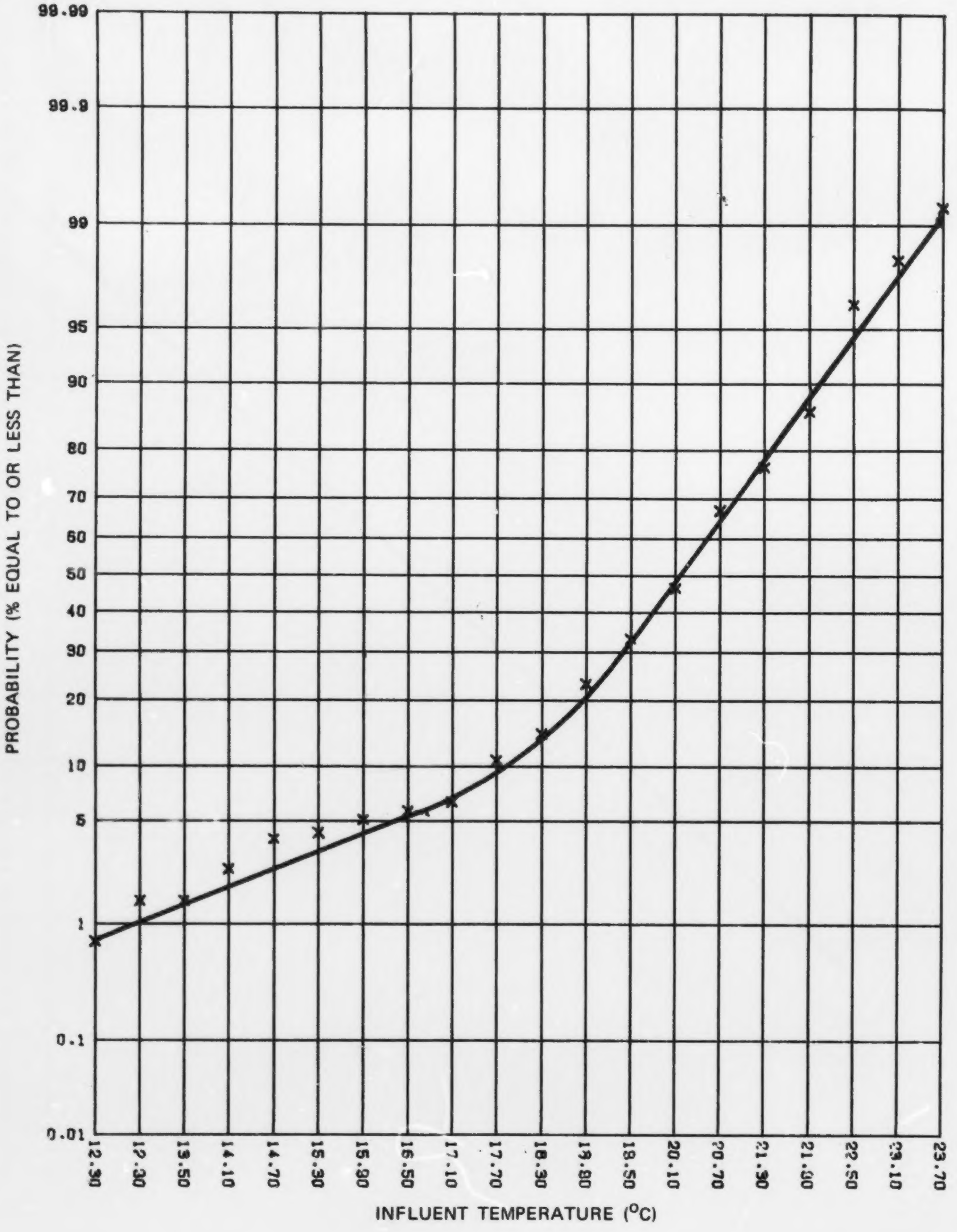


FIGURE C–4

PROBABILITY OF INFLUENT TEMPERATURE

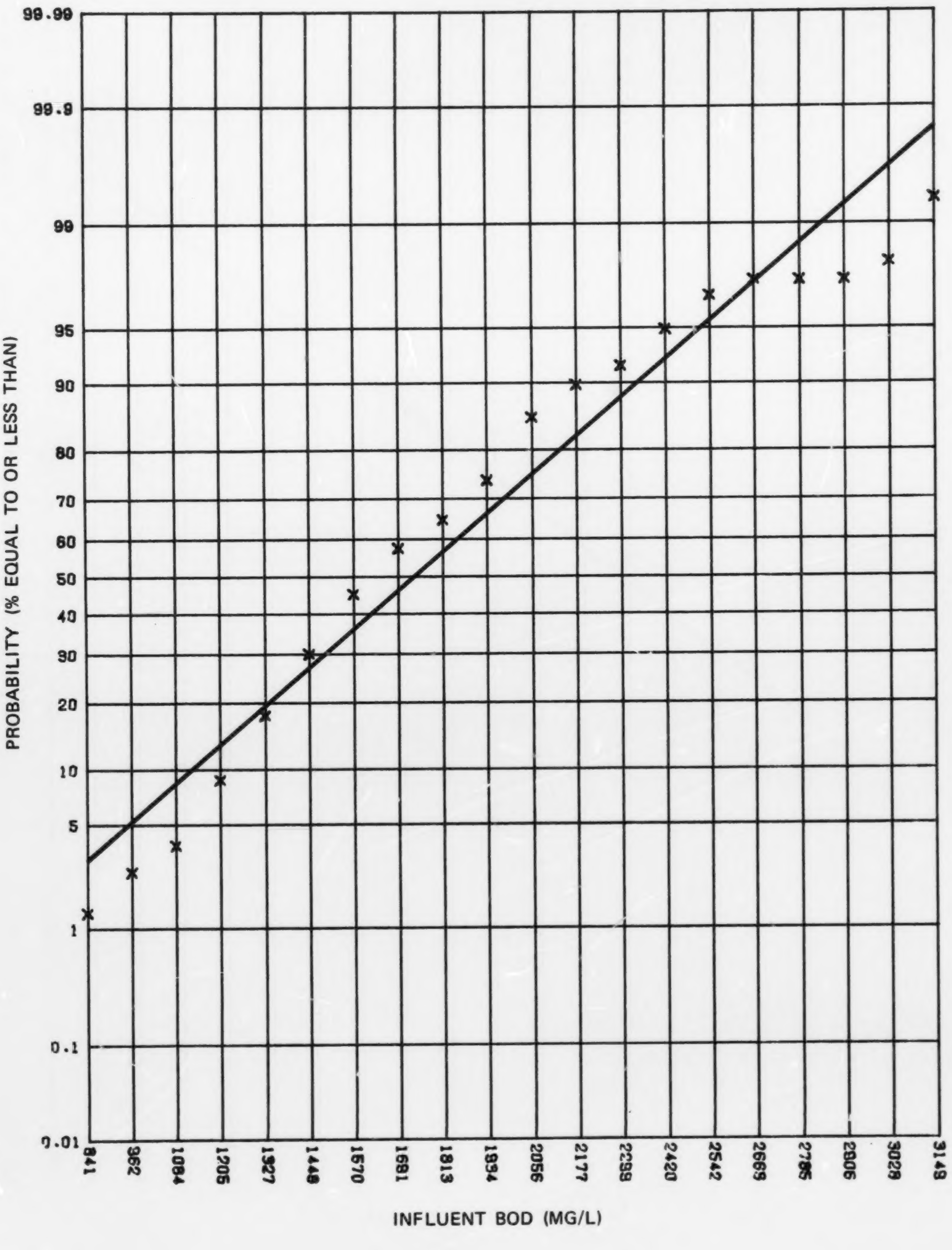


FIGURE C–5

PROBABILITY OF INFLUENT BOD

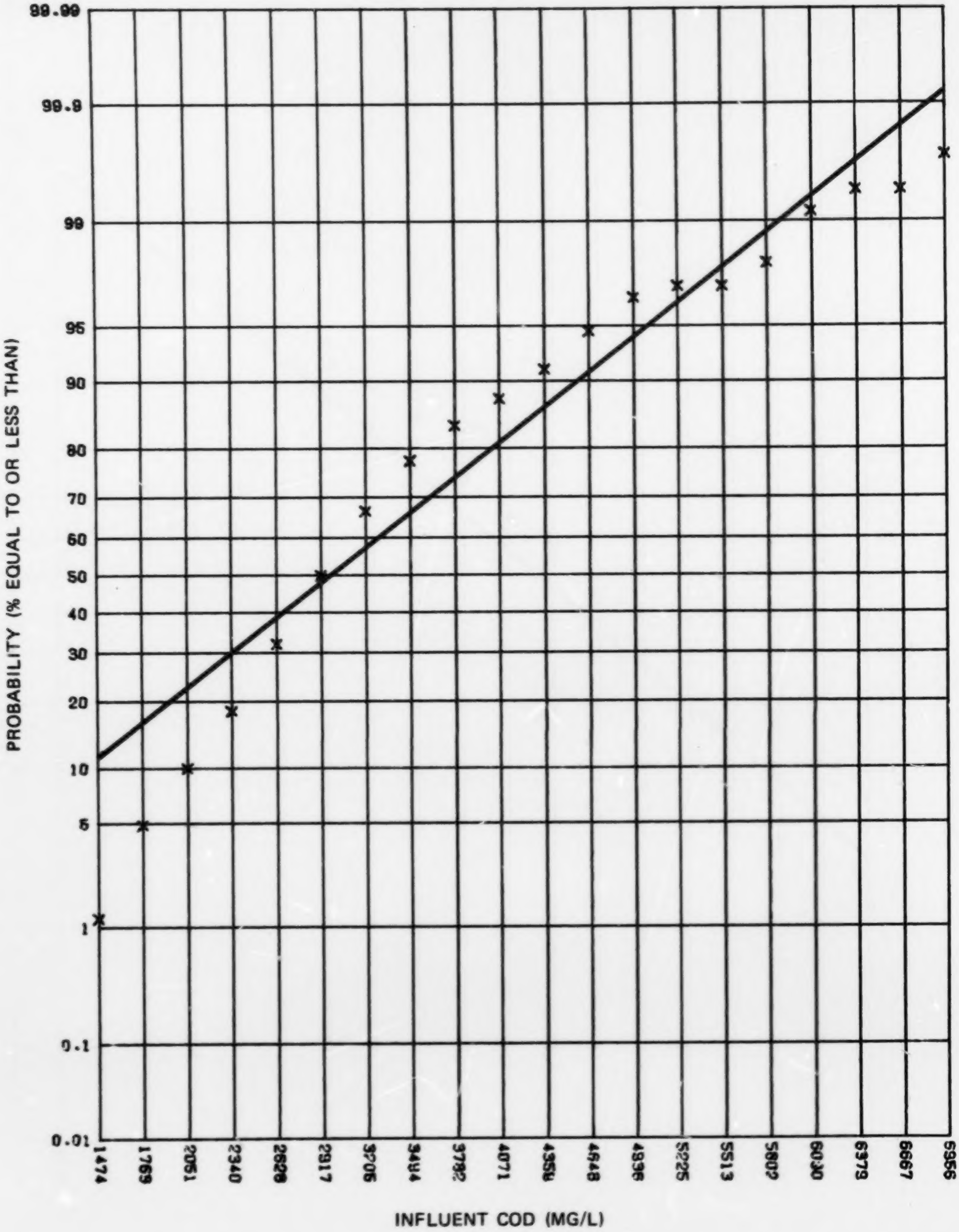


FIGURE C–6

PROBABILITY OF INFLUENT COD

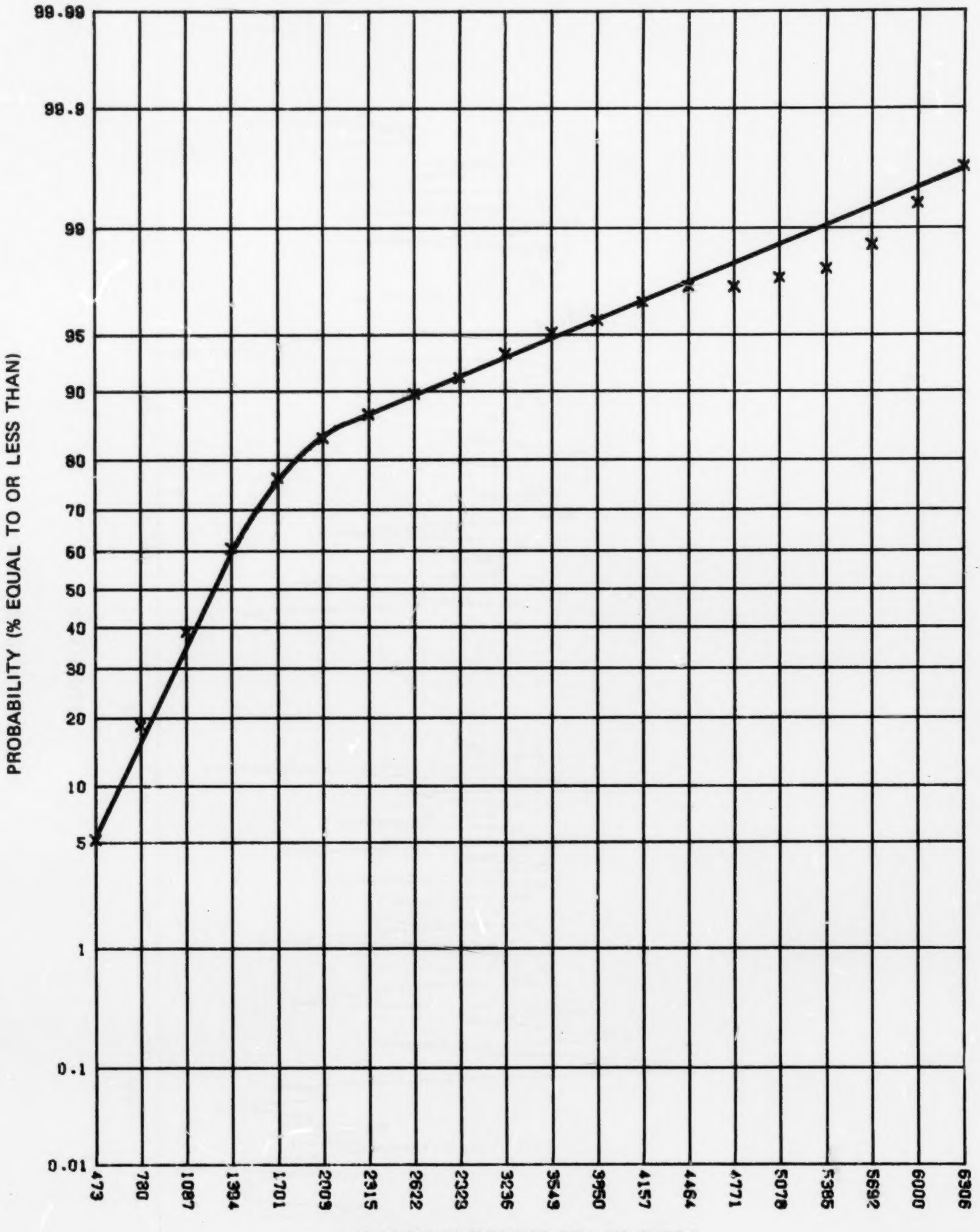


FIGURE C–7

PROBABILITY OF INFLUENT SUSPENDED SOLIDS

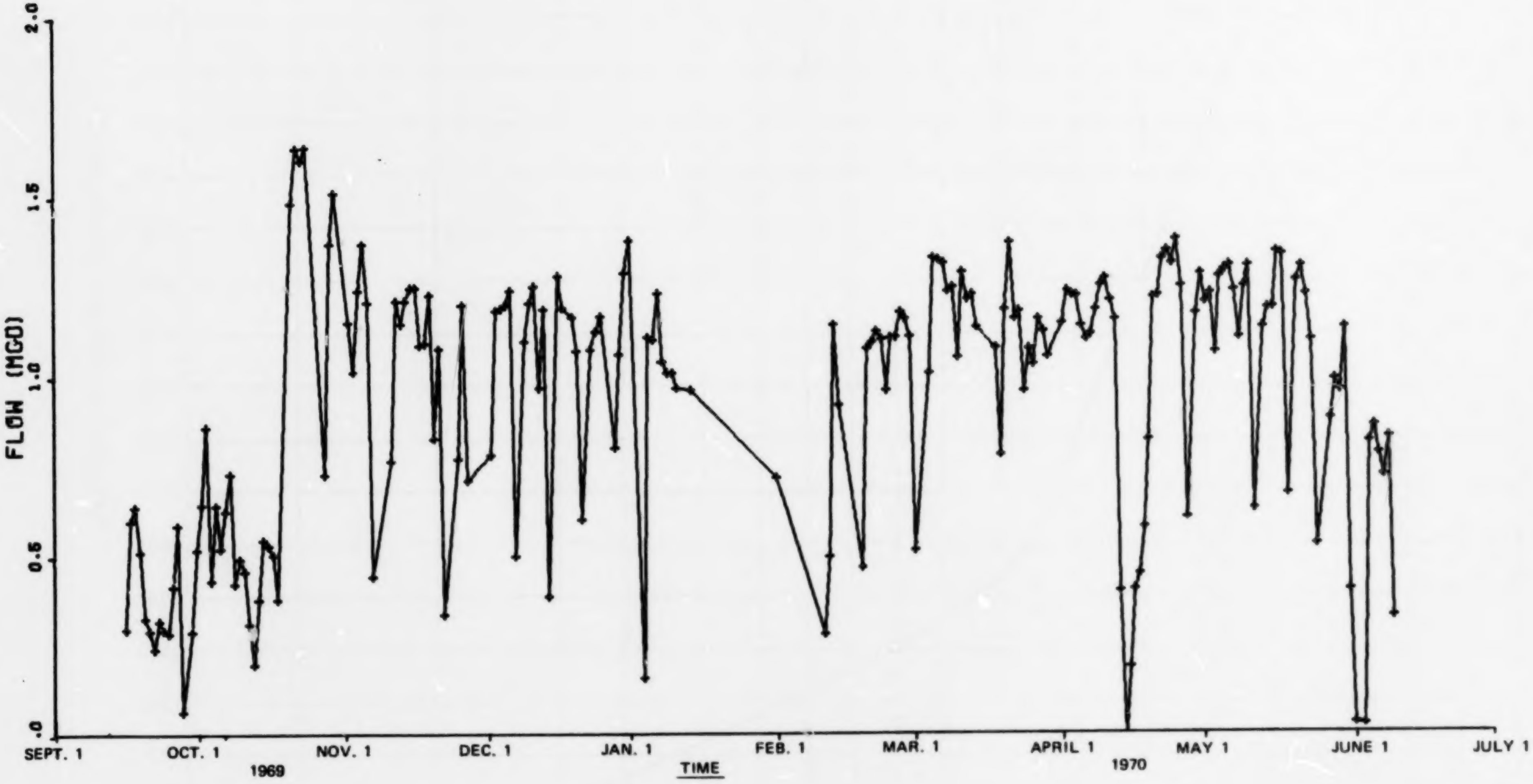


FIGURE C–8

INFLUENT FLOW VS. TIME

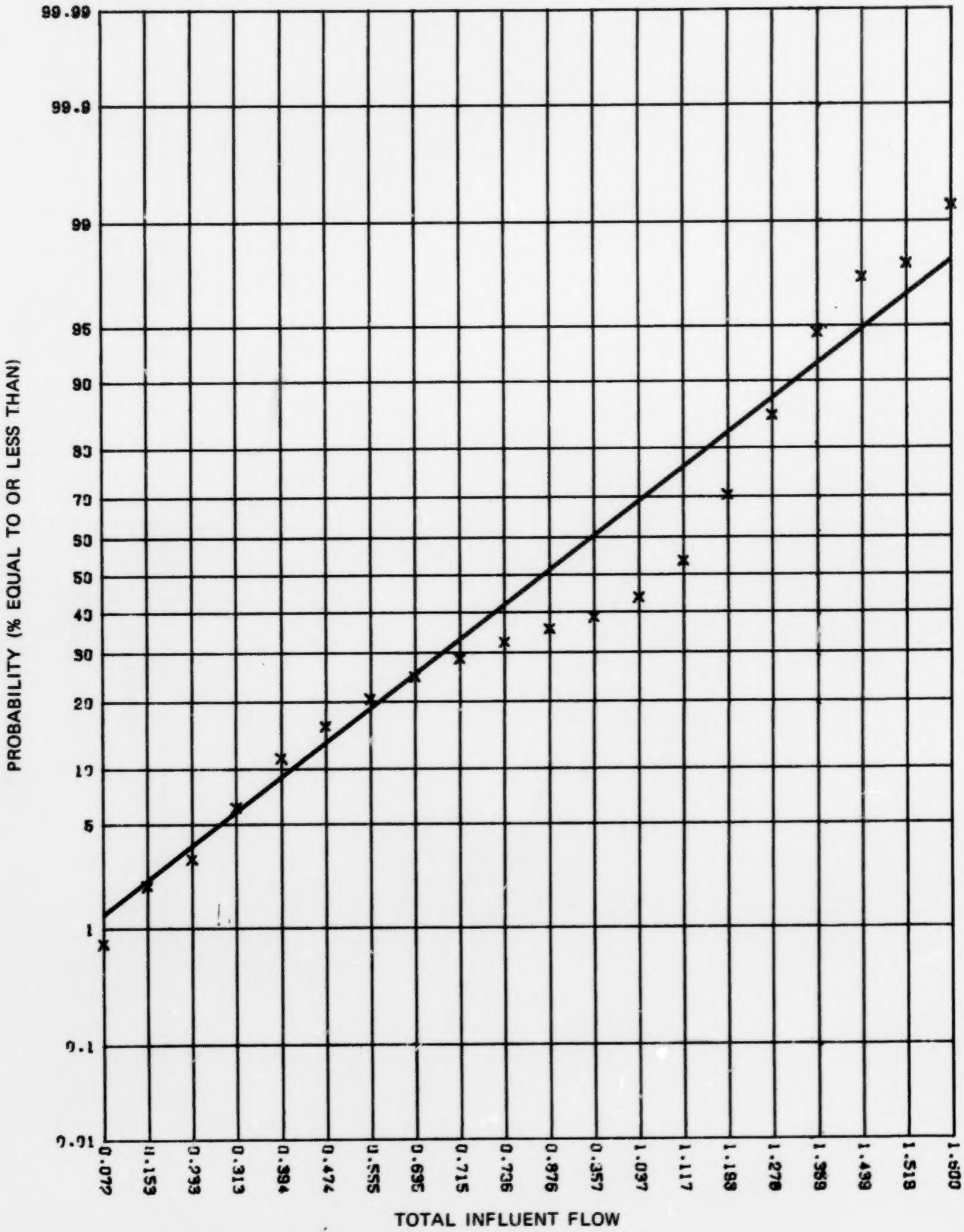


FIGURE C–9

PROBABILITY OF TOTAL INFLUENT FLOW

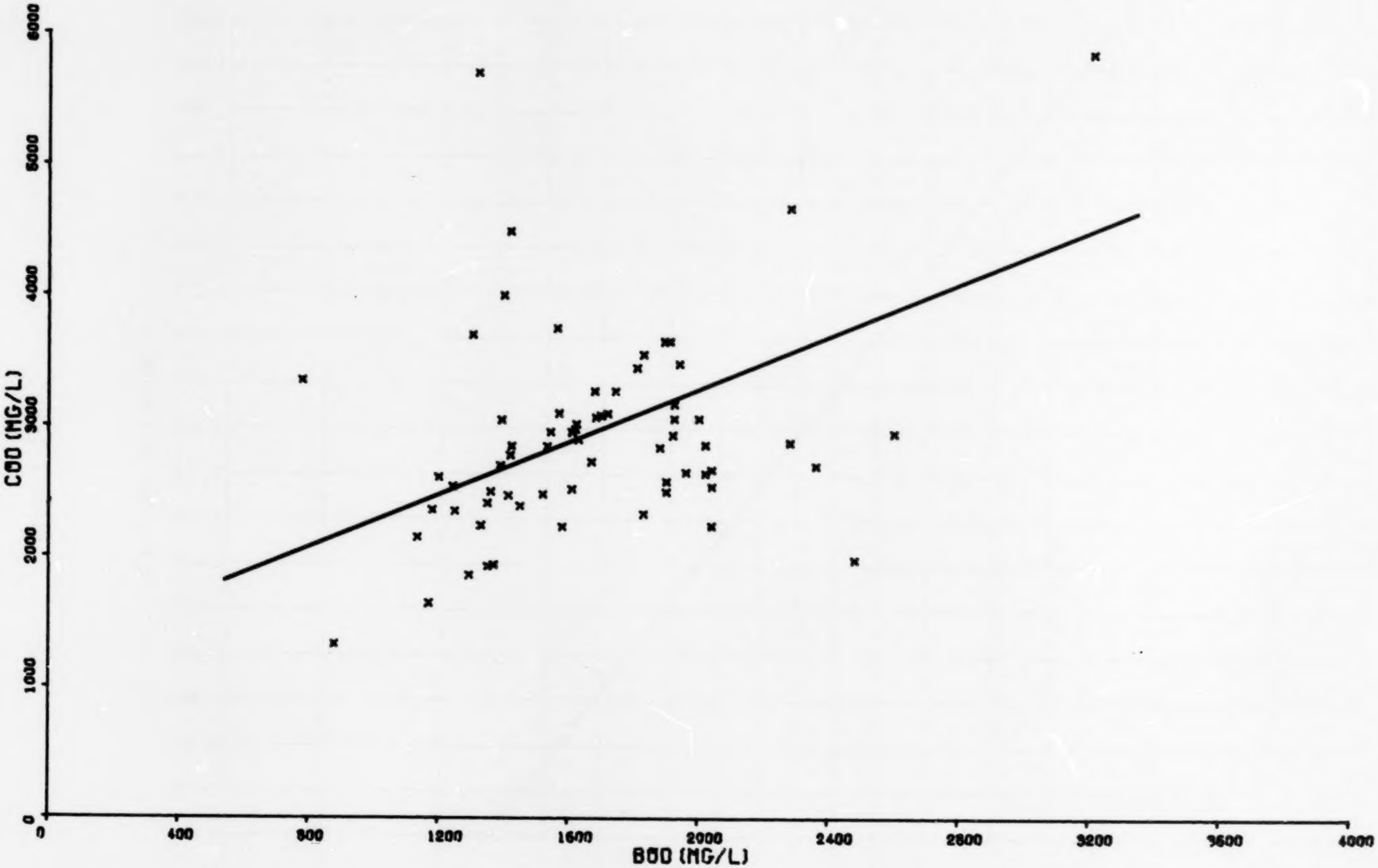


FIGURE C–10

INFLUENT BOD VS. COD
(ALL DATA)

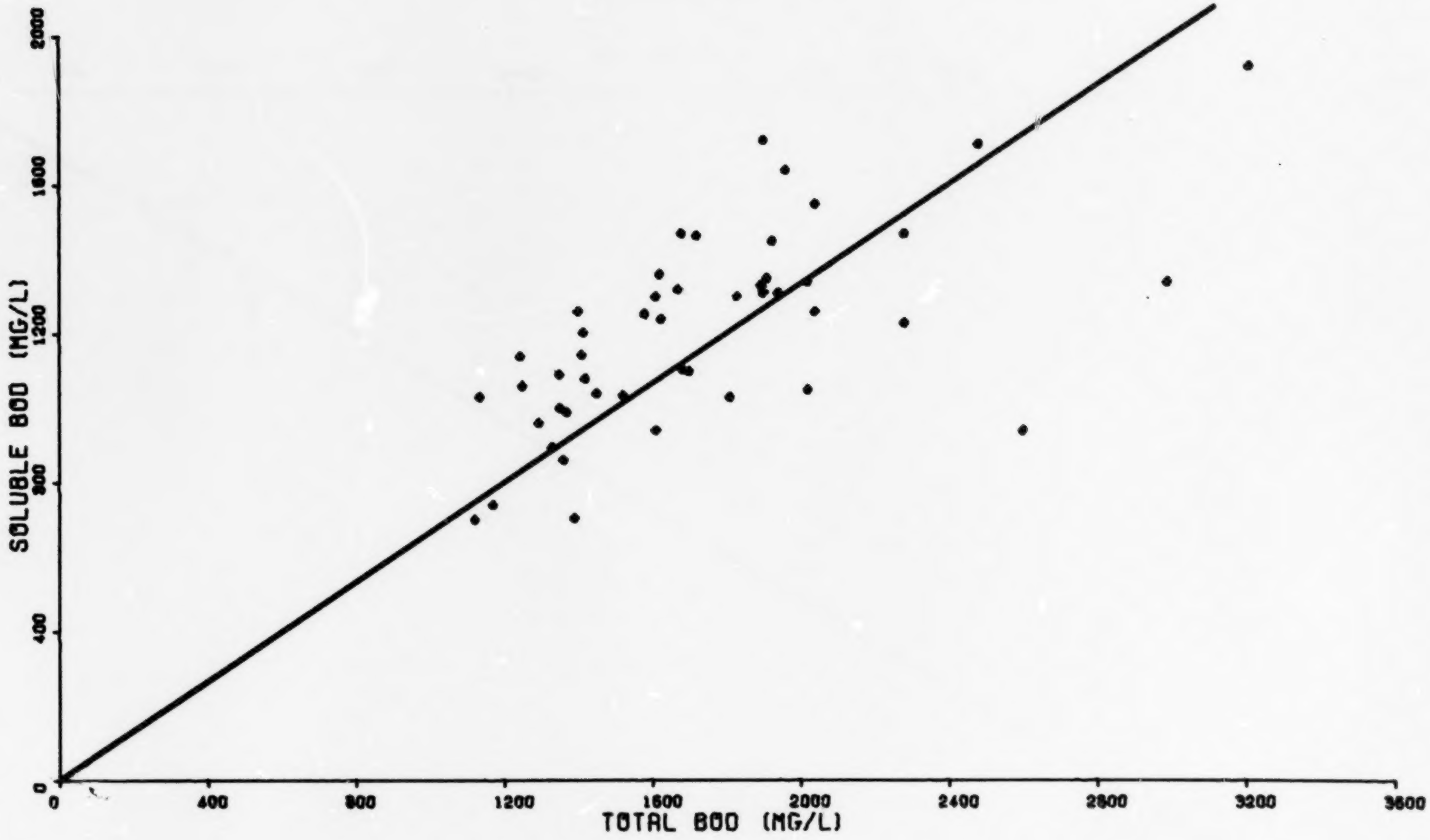


FIGURE C-11

INFLUENT TOTAL BOD VS. SOLUBLE BOD
(ALL DATA)

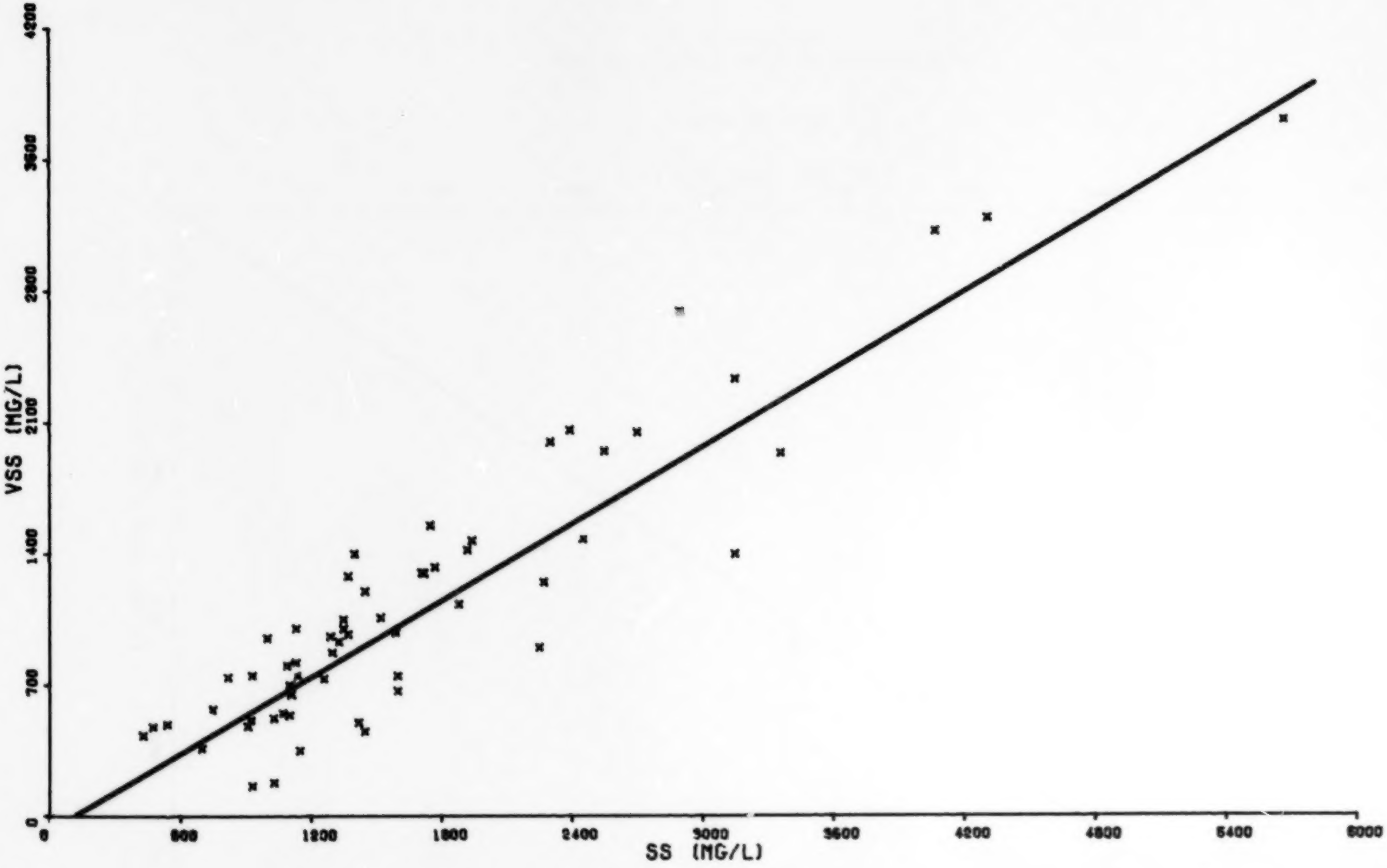


FIGURE C–12

INFLUENT SS VS. VSS
(ALL DATA)

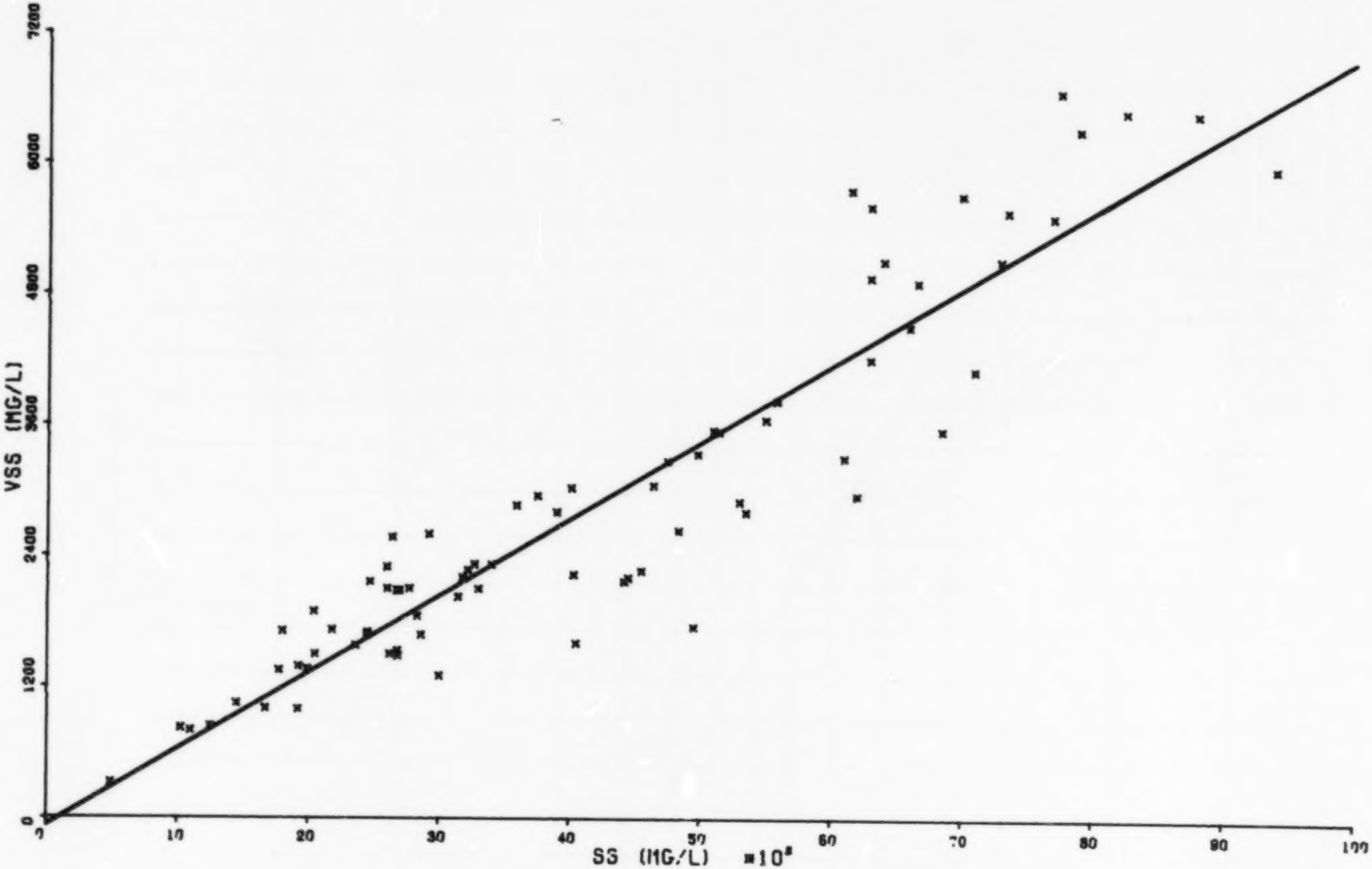


FIGURE C–13

BASIN SS VS. VSS
(ALL DATA)

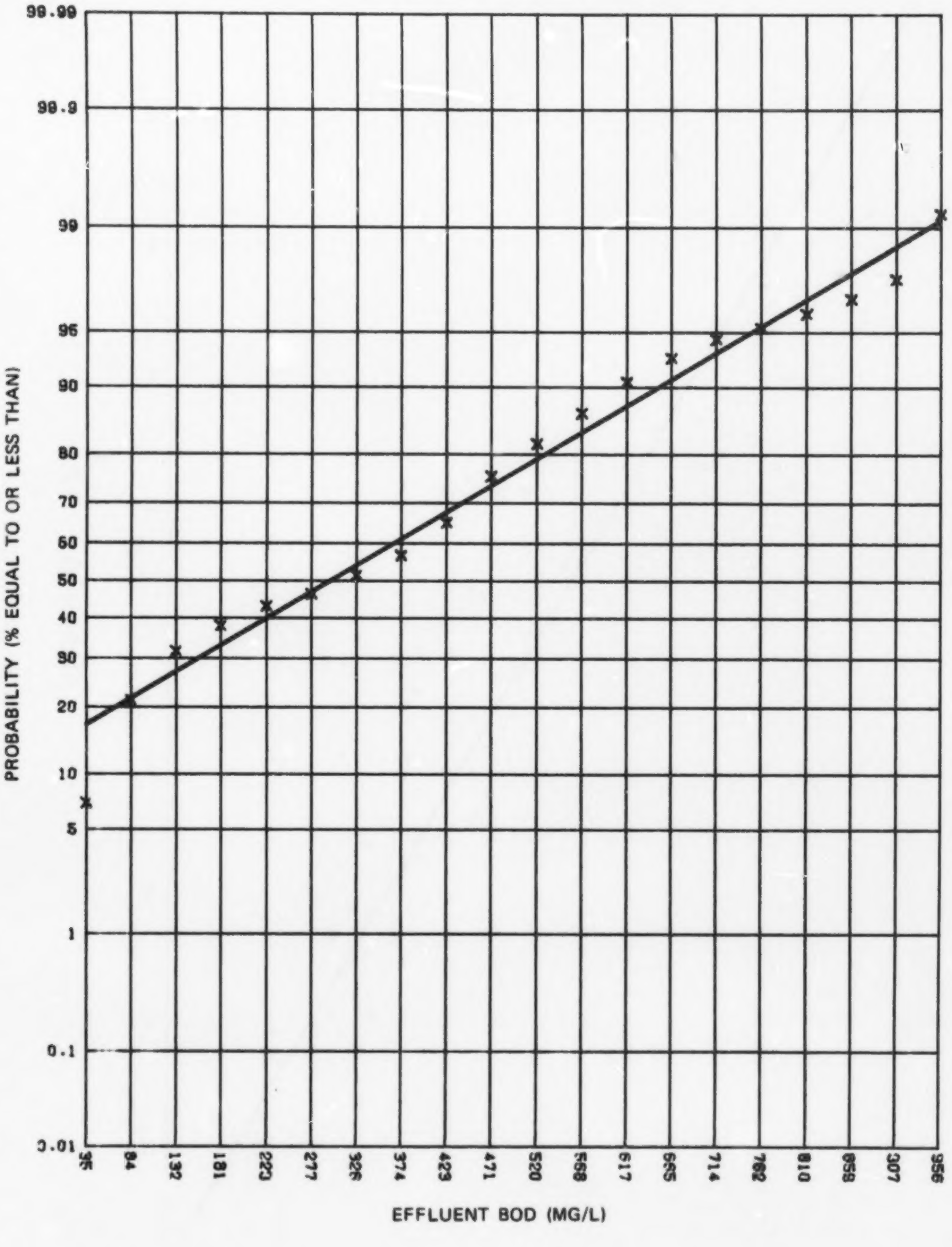


FIGURE C–14

PROBABILITY OF EFFLUENT BOD

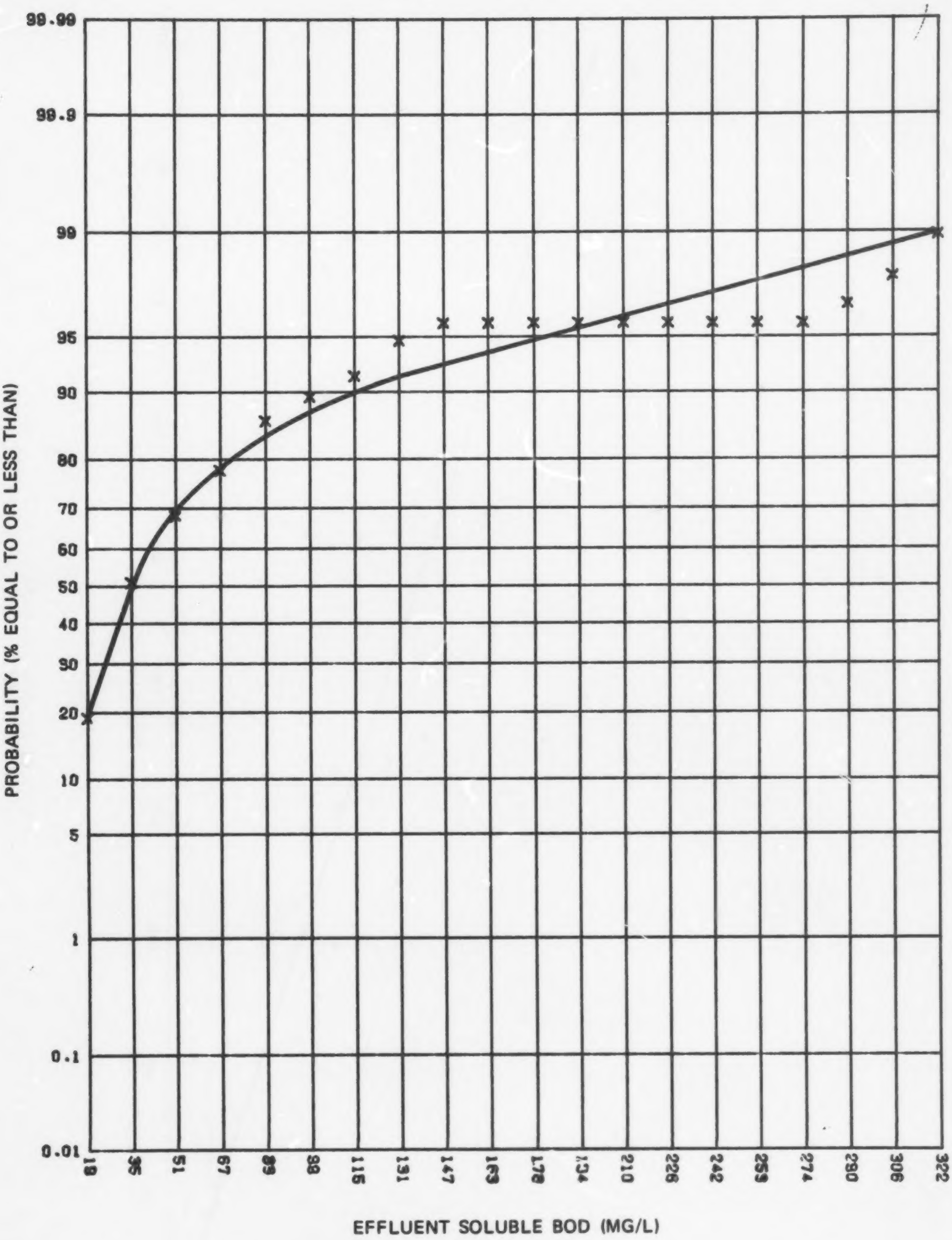


FIGURE C–15

PROBABILITY OF EFFLUENT SOLUBLE BOD

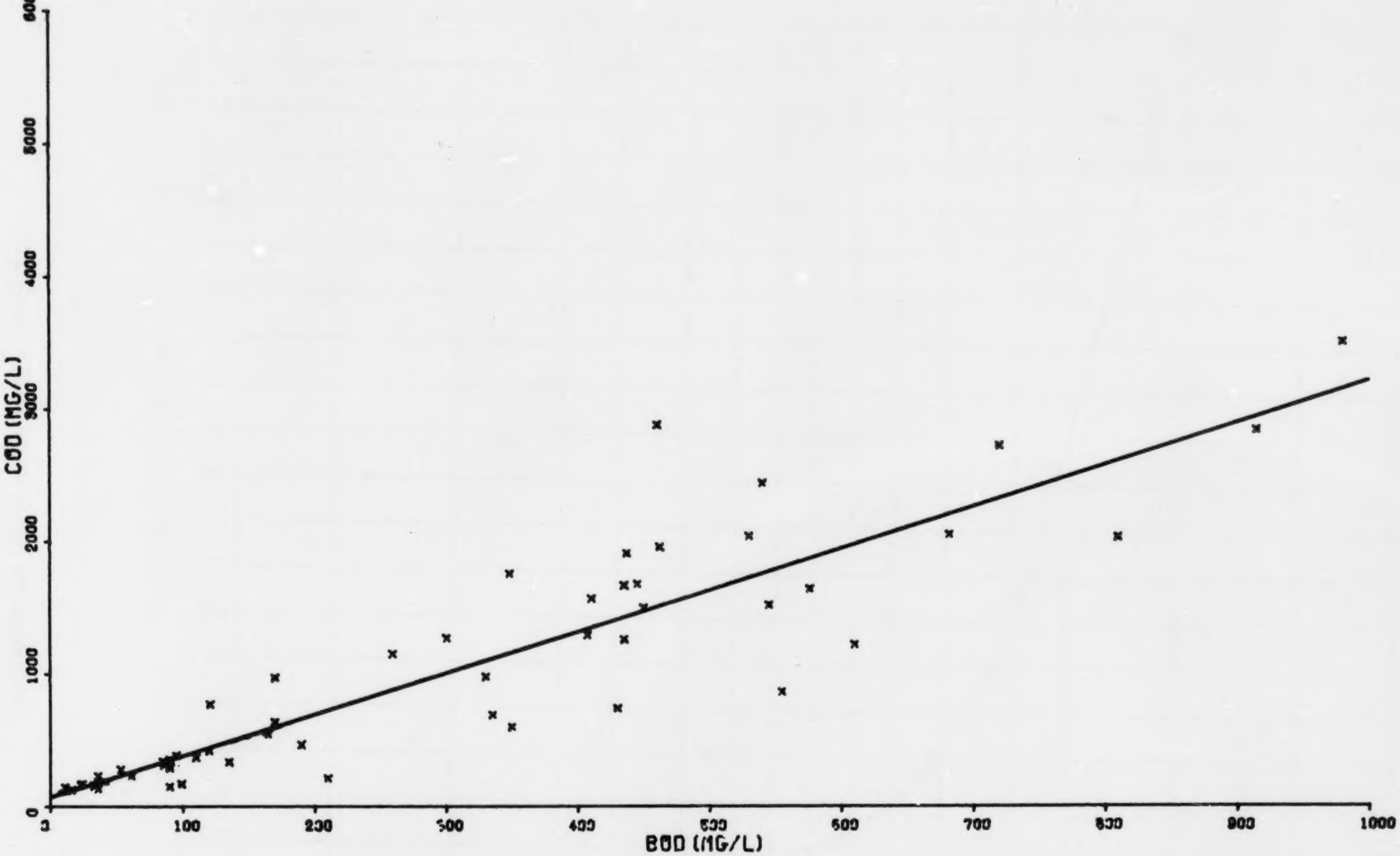


FIGURE C–16

EFFLUENT BOD VS. COD
(ALL DATA)

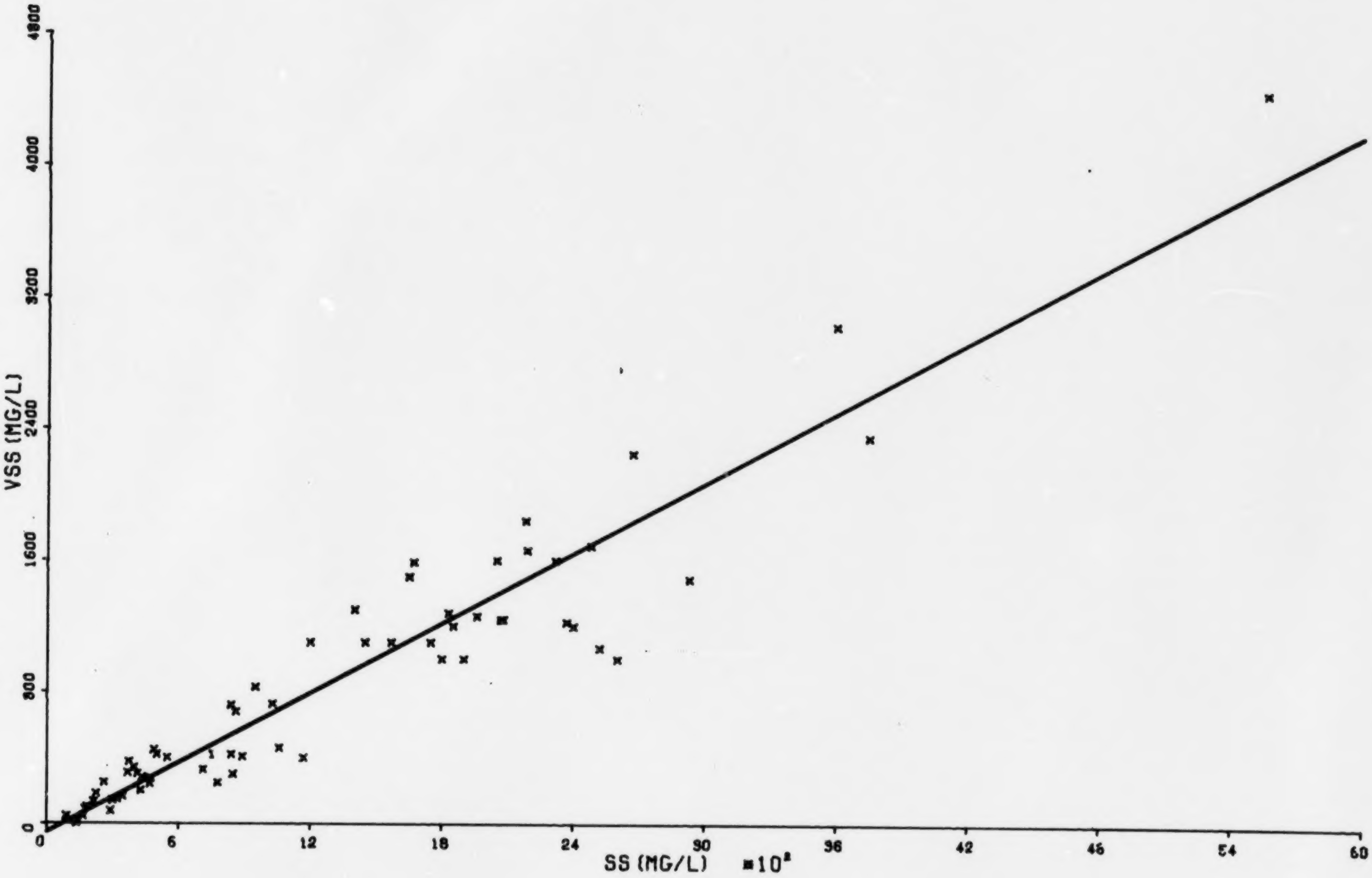


FIGURE C–17

EFFLUENT SS VS. VSS
(ALL DATA)

APPENDIX D

APPENDIX D
SAMPLING POINTS, SAMPLING SCHEDULE, AND TESTING EQUIPMENT

SAMPLING POINTS

1. TOTAL PLANT INFLUENT–The sample was taken from the influent pump discharge line, downstream from the influent pump pit, and pumped to the stock samplers in the control building. The sample point is shown as S-1 on Figure 2. The pump is located in the control building.

2. SILT WATER–The sample was taken from the silt water line to the clarifier-thickener, just inside the control building wall adjacent to the clarifier-thickener. It flows by pressure to the stock sampler adjacent to the sample point. The sample point is shown as S-2 on Figure 2. No pump was used to collect this sample.

3. CLARIFIED SILT WATER–The sample was taken from the bottom of the clarifier-thickener effluent launder and pumped to the stock samplers located in the control building. The sample point is shown as S-3 on Figure 2. The sample pump is located in the control building.

4. AERATION BASIN NO. 2 EFFLUENT–The sample was taken from the aeration basin inlet-outlet structure, near the bottom of the box just upstream from discharge Weir W-3, and pumped to the stock samplers in the control building. The sample point is shown as S-4 on Figure 2. The sample pump is located in the control building.

5. RETURN SLUDGE–The sample was taken from the recirculation sludge line, downstream from the valve and meter pit, and pumped to the stock samplers in the control building. The sample point is shown as S-5 on Figure 2. The sample pump is located in the control building.

6. WASTE SLUDGE–A grab sample was taken from the waste sludge line by opening Valve V-13, shown on Figure 2. The sample point is shown as S-6 on Figure 2.

7. FINAL PLANT EFFLUENT–The sample was taken from the secondary clarifier effluent line, just downstream from the secondary clarifier, and pumped to the stock samplers in the control building. The sample point is shown as S-7 on Figure 2. The sample pump is located in the control building.

8. PRIMARY TREATED PROCESS WATER–The sample was taken from the treated process water line at the meter manhole just upstream from the influent pump pit, and pumped to the stock samplers in the control building. The sample point is shown as S-8 on Figure 2, and the sample pump is located in the control building.

9. AERATION BASIN NO. 1 EFFLUENT–The sample was taken from the aeration basin inlet-outlet structure, near the bottom of the box upstream from discharge Weir W-2, and pumped to the stock samplers in the control building. The sample point is shown as S-9 on Figure 2. The sample pump is located in the control building.

10. FILTRATE–A grab sample was taken from the filtrate discharge line by opening Valve V-19, shown on Figure 2. The sample point is shown as S-10 on Figure 2.

TABLE D–1

SAMPLING AND TESTING SCHEDULE

NUMBER OF TESTS PER WEEK

SAMPLE POINT		C O D	B O D	SUSPENDED SOLIDS			TEMPERATURE	pH	DISSOLVED OXYGEN	COLIFORMS	NITROGEN		PHOSPHOROUS	SLUDGE VOLUME INDEX	Cl_2 BREAK POINT	DEWATER-ABILITY	MICROSCOPIC EXAMINATION	ALKALINITY	OXYGEN UPTAKE RATE	SODIUM
				TOTAL	VOLATILE	SETTLEABLE					TOTAL	NO_3								
1	TOTAL PLANT INFLUENT	5	2	5	1	5	5	CONT.	-	1	1	1	1	-	1	-	-	1	1	-
9	AERATION POND NO. 1 EFFLUENT	5	2	5 OR MORE	2	5	CONT.	5	10	-	1	1	1	5	-	-	1	1	1	-
4	AERATION POND NO. 2 EFFLUENT	5	2	5 OR MORE	2	5	CONT.	5	10	-	-	-	-	5	1	-	1	1	1	-
5	RETURN SLUDGE	1	-	5	5	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-
7	FINAL PLANT EFFLUENT	5	2	5	1	5	5	1	5	1	1	1	1	-	1	-	-	-	-	1
2	SILT WATER	2	1	3	1	3	1	1	-	1	-	-	-	-	-	1	-	-	-	-
3	CLARIFIED SILT WATER	5	2	3	1	1	1	1	-	1	1	1	1	-	-	-	-	1	-	-
10	FILTRATE	1	1	5	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
8	PRIMARY TREATED PROCESS WATER	5	2	5	1	5	5	5	-	1	1	1	1	-	1	-	-	1	1	-
6	WASTE SLUDGE	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE D–2

TESTING EQUIPMENT

	ITEM	MANUFACTURER	MODEL	OPERATING RANGE	ACCURACY
1.	INCUBATOR CABINET TEMPERATURE CONTROL	GENERAL ELECTRIC N–CON, INC.		20° C	±1° C
2.	REFRIGERATOR	GENERAL ELECTRIC		35° C	±2° C
3.	pH METER	SARGANT	54	0–14	± 0.05
4.	ANALYTICAL BALANCE	METTLER	H 10 TW	0–160g	± 0.0001g
5.	MUFFLE FURNANCE	THERMOLYNE	F-D1525M	550° C	±10° C
6	DRYING OVEN	NATIONAL APPLIANCE CO.	420	103° C	±1° C
7.	VACUUM PUMP	GELMAN	13400	20" HG	± 0.5 "HG
8.	ION EXCHANGE COLUMN	BARNSTEAD			
9.	DISSOLVED OXYGEN PROBE FIELD PROBE BOD BOTTLE PROBE	YELLOW SPRINGS INSTRUMENT CO.	54	0–10 MG/L	± 0.1 MG/L
10.	SPECTROPHOTOMETER	BAUSCH & LOMB	SPEC.–20		
11.	PHOTO BINOCULAR MICROSCOPE	BAUSCH & LOMB	PG252		
12.	CURRENT METER	A. OFF	C1		

APPENDIX E

cc. CWB
6-14-70
(CE)

Ricks College
REXBURG, IDAHO 83440

JOHN L. CLARKE, PRESIDENT

BIOLOGICAL SCIENCES

June 13, 1970

Mr. Lynne Sirrine
The R.T.French Company
P.O.Box Drawer AA
Shelley, Idaho

Dear Lynne,

This is a report on our findings of the waste disposal sample which we received from you the week of June 8th. Our examination of the organism you designated has been a preliminary examination only.

Our results show that the orgaism is not a bacterium; it is likely a fungus. We do not have a mycologist on our staff, for this reason we were unable to identify the organism for you.

The bacteria found, which were long filamentous rods, belonged to the genus Bacillus. No other long filamentous bacteria were observed.

Kindest personal regards,

Lyle J. Lowder

TO
Glenn Richter
CH$_2$M

FROM
THE R. T. FRENCH CO.
SHELLEY, IDAHO

SUBJECT Dr. Sowder's letter of June 13, 1970

DATE 7/13/70

MESSAGE:
Glenn - Dr. Sowder told me over the phone a few things that aren't mentioned in his letter. He said that they carried the identification of the filamentous growth far enough to know that it is a fungus. This apparently was done by the type agar used, pH control as well as temperature and etc.

ORIGINATOR-DO NOT WRITE BELOW THIS LINE

REPLY TO ⟶ SIGNED KCS

REPLY

RECEIVED
JUL 16 1970
CH$_2$M
Corvallis, Ore.

DATE

SIGNED

SEND PARTS 1 AND 3 INTACT-PART 1 WILL BE RETURNED WITH REPLY

RM-67

E-2

RETURN TO ORIGINATOR

LABORATORY REPORT

July 21, 1970

LAB. NUMBER 5513
DATE RECEIVED July 2, 1970

Sample, potato waste: as received basis

pH	6.6
Moisture	94.5 %
Protein	1.9 %
Fat	.02 %
Fiber	.16 %
Ash	1.64 %
NFE	1.78 %
TDN	2.7 %
Calcium	0.25 %
Phosphorous	0.051 %
Iron	0.0028 %
Sodium	0.099 %

Pesticide residue report will follow.

R. T. French Co.
P. O. Drawer AA
Shelley, Idaho 83274
ATTN: Mr. K. L. Sirrine

PHONE 343-7830
HIBBS LABORATORIES
2808 CASSIA
BOISE, IDAHO 83705

LABORATORY REPORT

Feb. 7, 1971

LAB. NUMBER 5513
DATE RECEIVED Sept. 23, 1970

Waste: Activated sludge sample from R.T.French, Shelley, Idaho:

Pesticide residue by G.L.C. electron-capture.
Results: nil

Pesticides: Standards used	Detection limit ppm
Lindane	.005
Aldrin	.01
Heptachlor epoxide	.01
Dieldrin	.05
Endrin	.05
DDE	.05
DDD	.1
DDT	.1
Methoxychlor.	.2

Cornell Howland Hayes & Merryfield
1600 Western Blvd.
Corvallis, Oregon
ATTN: Mr. Glen Richter.

HIBBS LABORATORIES
PHONE 343-7830
2808 CASSIA BOISE, IDAHO 83705

APPENDIX F

TABLE F-1

THE R. T. FRENCH COMPANY
Shelley, Idaho

SECONDARY WASTE TREATMENT FACILITY CONSTRUCTION COSTS

ITEM	TOTAL COSTS	ESTIMATED TOTAL COSTS LESS DEMONSTRATION COSTS
Control Building		
Building, Complete	$ 33,884.56	$ 20,000
Influent Pumps	12,768.40	12,768
Influent Pump Wet Well	8,163.61	8,164
Sludge Pumps	9,788.25	9,788
Sample Pumps and Samples	17,470.80	
Continuous Temperature Recording	4,705.72	
Laboratory Equipment and Supplies	6,389.19	
Flow Metering Equipment	11,842.85	11,843
Aeration Equipment	87,123.85	50,000
Secondary Clarifier and Sludge Recirculation Station	51,811.94	40,000
Aeration Basin and Miscellaneous Earthwork		
Earthwork	18,809.93	12,000
Plastic Sheet Liner	18,825.00	8,000
Influent Splitter Boxes	2,322.10	
Outlet Boxes	3,953.11	
Inlet Header Piping	6,808.50	6,500
Outlet Piping to Clarifier	6,146.55	6,000
Miscellaneous Outside Piping and Plumbing		
Sample Lines, Washwater Lines, and Hydrants	5,167.02	
Water Source	2,312.46	2,312
Sludge Piping	6,731.04	6,000
Pipe from Waste Solids System	650.00	650
Gravity Influent from Processing Plant	14,628.45	14,628
Gravity Outfall to Existing Storm Sewer in Fir Street	13,418.71	13,419

TABLE F-1 - CONTINUED

Waste Solids System		
Filter	$ 30,810.68	$ 30,811
Intercept Silt Water, Screen, Pump, and Pipe to Waste Solids System	54,971.38	54,971
Clarifier-Thickener	29,254.66	29,255
Solids Pump	1,823.85	1,824
Solids Bunker	3,419.26	3,419
Electrical		
Primary Transformer and Meter	6,499.78	6,500
In-Plant Electrical	28,693.72	28,500
Electrical Building	2,464.00	2,464
Painting	830.70	500
Gravel Roadway and Parking	2,491.02	2,491
Fence	4,404.00	4,404
Cleanup and Miscellaneous	650.00	650
Move-in and Temporary Facilities	2,300.00	2,000
Bond and Insurance	2,530.00	2,530
Design, Engineering, Inspection and Supervision	78,135.69	34,000
Legal and Administrative	4,987.60	4,988
TOTAL	$598,104.94	$431,379

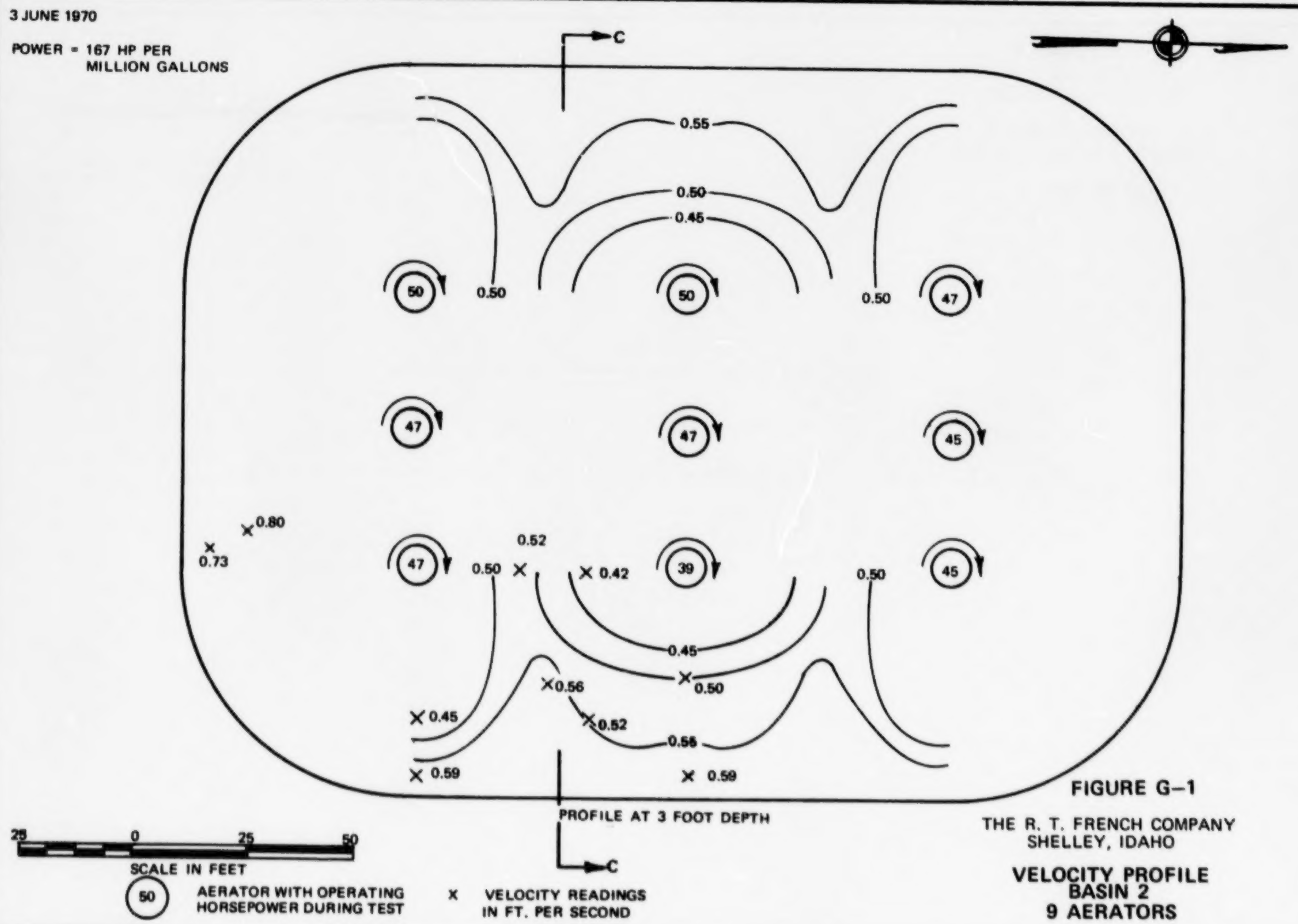
TABLE F-2

THE R. T. FRENCH COMPANY
Shelley, Idaho

SECONDARY WASTE TREATMENT FACILITY OPERATION AND MAINTENANCE COSTS

ITEM	TOTAL COSTS	ESTIMATED TOTAL COSTS LESS DEMONSTRATION COSTS
Operating Staff		
Laboratory Technician	$ 4,685.14	$ 4,685.14
Clerk-Typist	3,702.51	3,702.51
Chemist-Operator	9,718.83	9,718.83
Professional Staff	19,441.53	
Power	23,498.90	23,498.90
Maintenance		
Labor	7,647.65	7,647.65
Parts	5,824.17	5,824.17
Improvements and Spreading on Site	6,973.64	6,973.64
Solids Disposal	1,777.69	1,777.69
Laboratory Supplies	5,391.73	5,391.73
Operating Supplies	2,227.82	2,227.82
Outside Laboratory Testing	82.90	82.90
Preparation of Project Reports	751.59	
Transportation	556.35	
On-Site Living Expense	150.40	
Telephone	781.61	730.60
TOTAL	$93,212.46	$72,261.58

APPENDIX G



C
0.55
0.50
0.45
0.50
0.50
50
50
47
47
47
45
47
39
45
0.80
0.73
0.52
0.50
0.42
0.50
0.45
0.50
0.56
0.45
0.52
0.56
0.59
0.59
25
0
25
50
SCALE IN FEET
C
50
AERATOR WITH OPERATING HORSEPOWER DURING TEST
x
VELOCITY READINGS IN FT. PER SECOND

3 JUNE 1970

POWER = 167 HP PER MILLION GALLONS

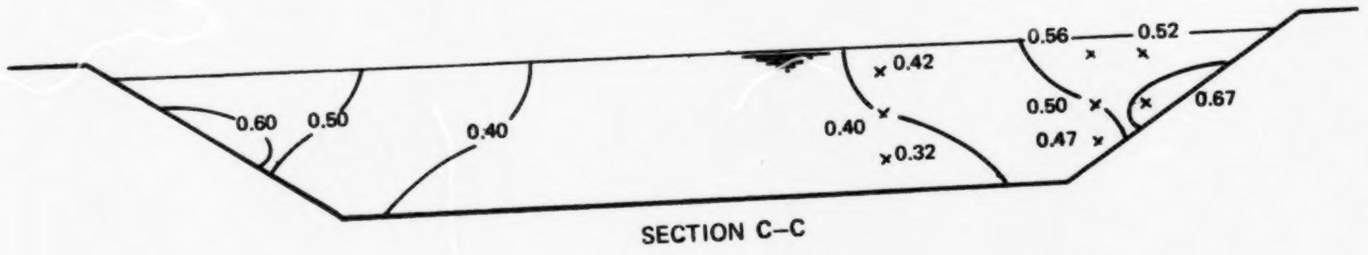
PROFILE AT 3 FOOT DEPTH

FIGURE G–1

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

VELOCITY PROFILE
BASIN 2
9 AERATORS

3 JUNE 1970

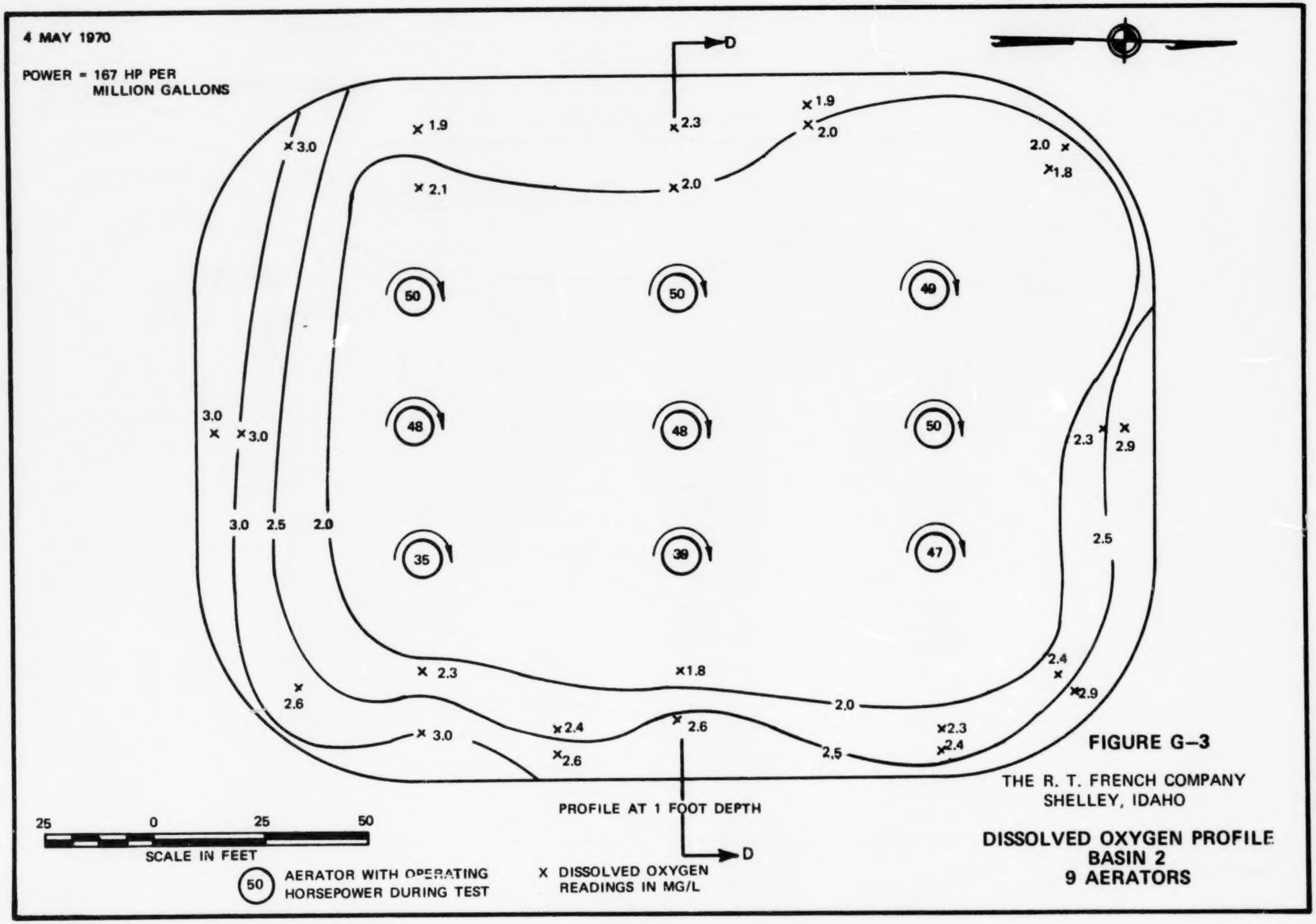

0.56
0.52
0.42
0.50
0.67
0.47
0.40
0.32
0.40
0.60
0.50
x VELOCITY READINGS IN FT. PER SECOND
20
0
20
40
SCALE IN FEET

SECTION C–C

FIGURE G–2

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

VELOCITY PROFILE
BASIN 2
9 AERATORS


D
1.9
2.3
1.9
2.0
3.0
2.0
1.8
2.1
2.0
50
50
49
3.0
3.0
48
48
50
2.3
2.9
3.0
2.5
2.0
35
39
47
2.5
2.4
2.3
1.8
2.6
2.9
2.0
2.4
2.6
2.3
3.0
2.6
2.5
2.4
25
0
25
50
SCALE IN FEET
D
50
AERATOR WITH OPERATING HORSEPOWER DURING TEST
X DISSOLVED OXYGEN READINGS IN MG/L

4 MAY 1970

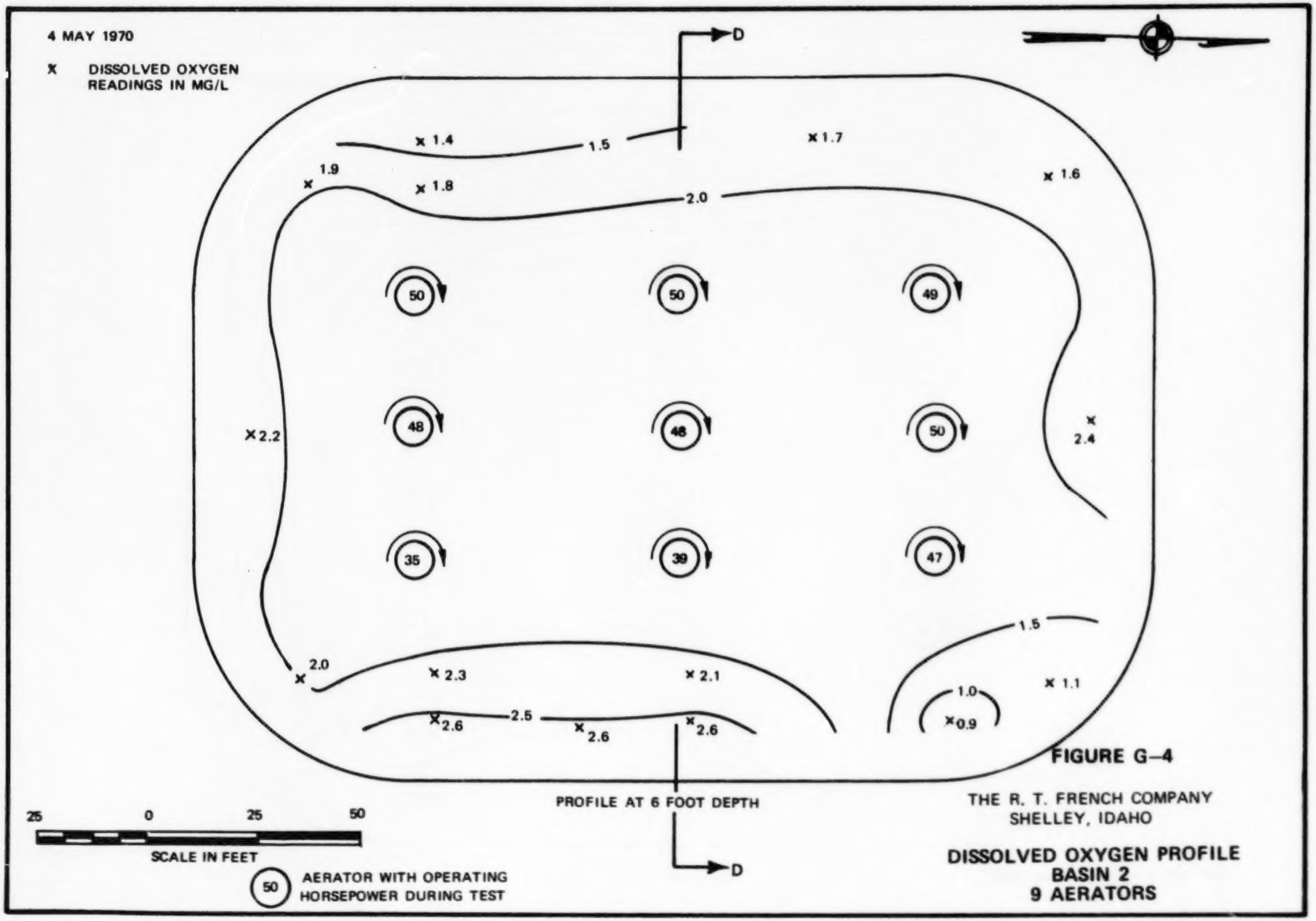
POWER = 167 HP PER MILLION GALLONS

PROFILE AT 1 FOOT DEPTH

FIGURE G–3

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 2
9 AERATORS



4 MAY 1970
X DISSOLVED OXYGEN READINGS IN MG/L
D
x 1.4
1.5
x 1.7
x 1.6
1.9
x
x 1.8
2.0
50
50
49
x 2.2
48
48
50
x 2.4
35
39
47
1.5
2.0
x 2.3
x 2.1
x 1.1
1.0
x 0.9
x 2.6
2.5
x 2.6
x 2.6
PROFILE AT 6 FOOT DEPTH
D
25
0
25
50
SCALE IN FEET
50 AERATOR WITH OPERATING HORSEPOWER DURING TEST

FIGURE G–4

THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 2
9 AERATORS

4 MAY 1970

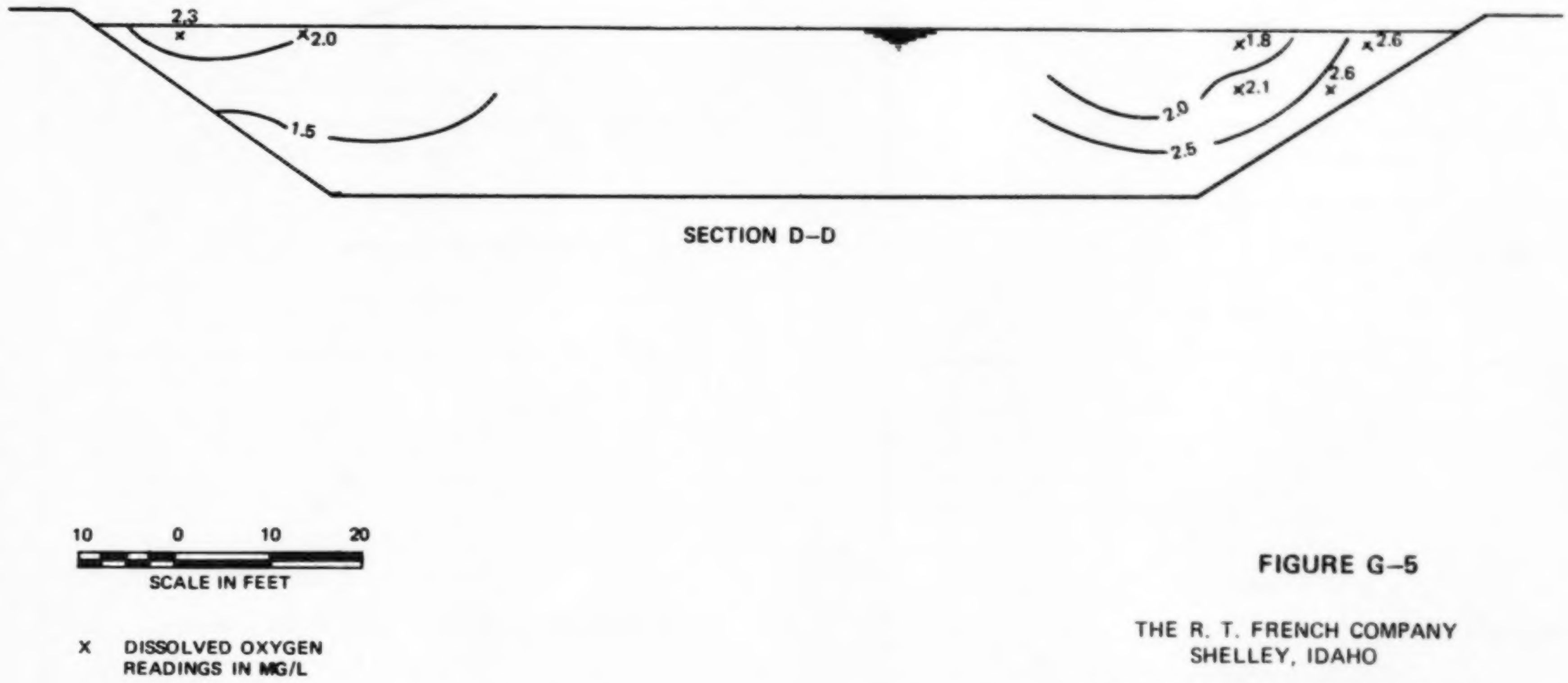
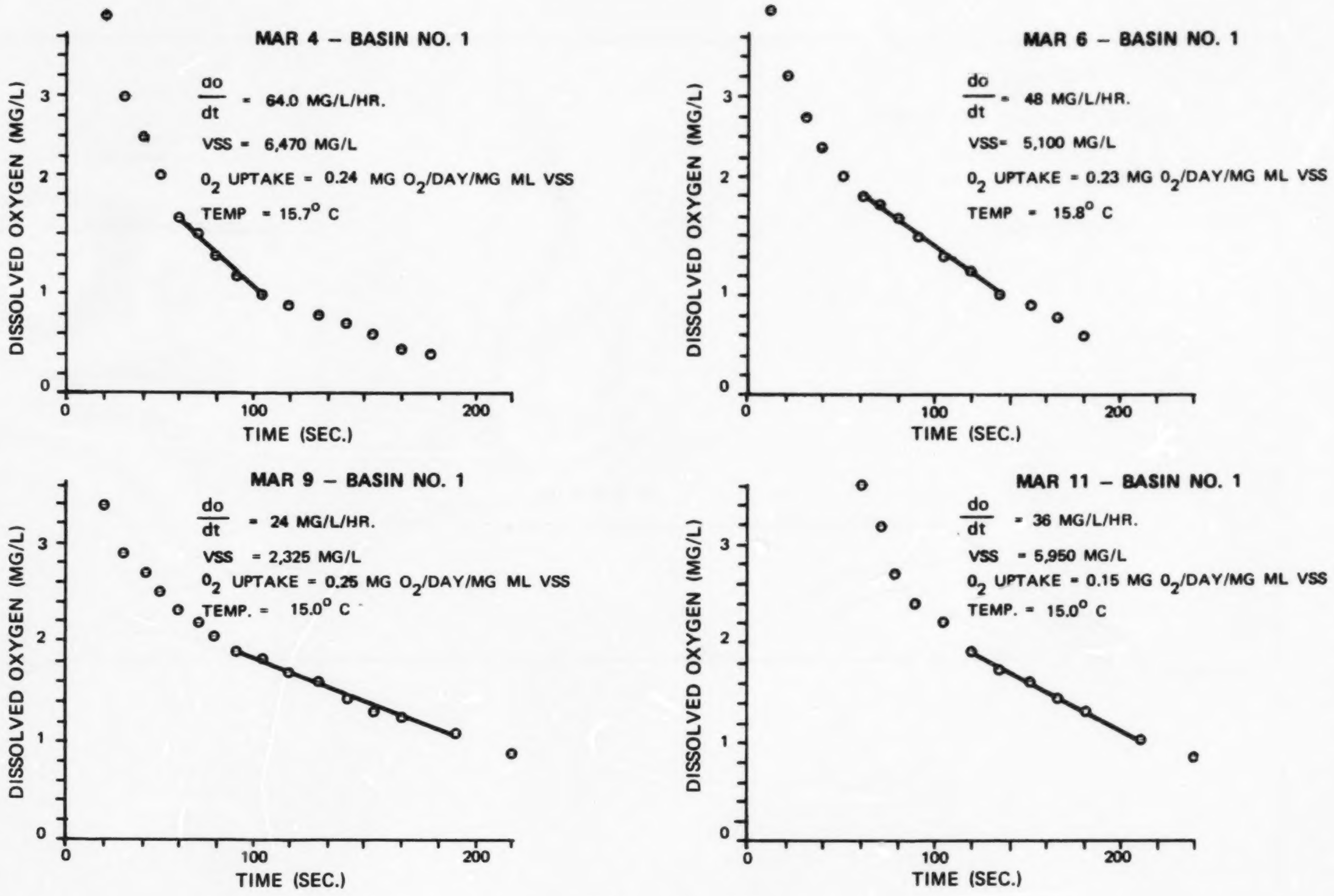

2.3
2.0
1.5
1.8
2.1
2.6
2.6
2.0
2.5
SECTION D–D
10
0
10
20
SCALE IN FEET
X DISSOLVED OXYGEN READINGS IN MG/L

FIGURE G–5

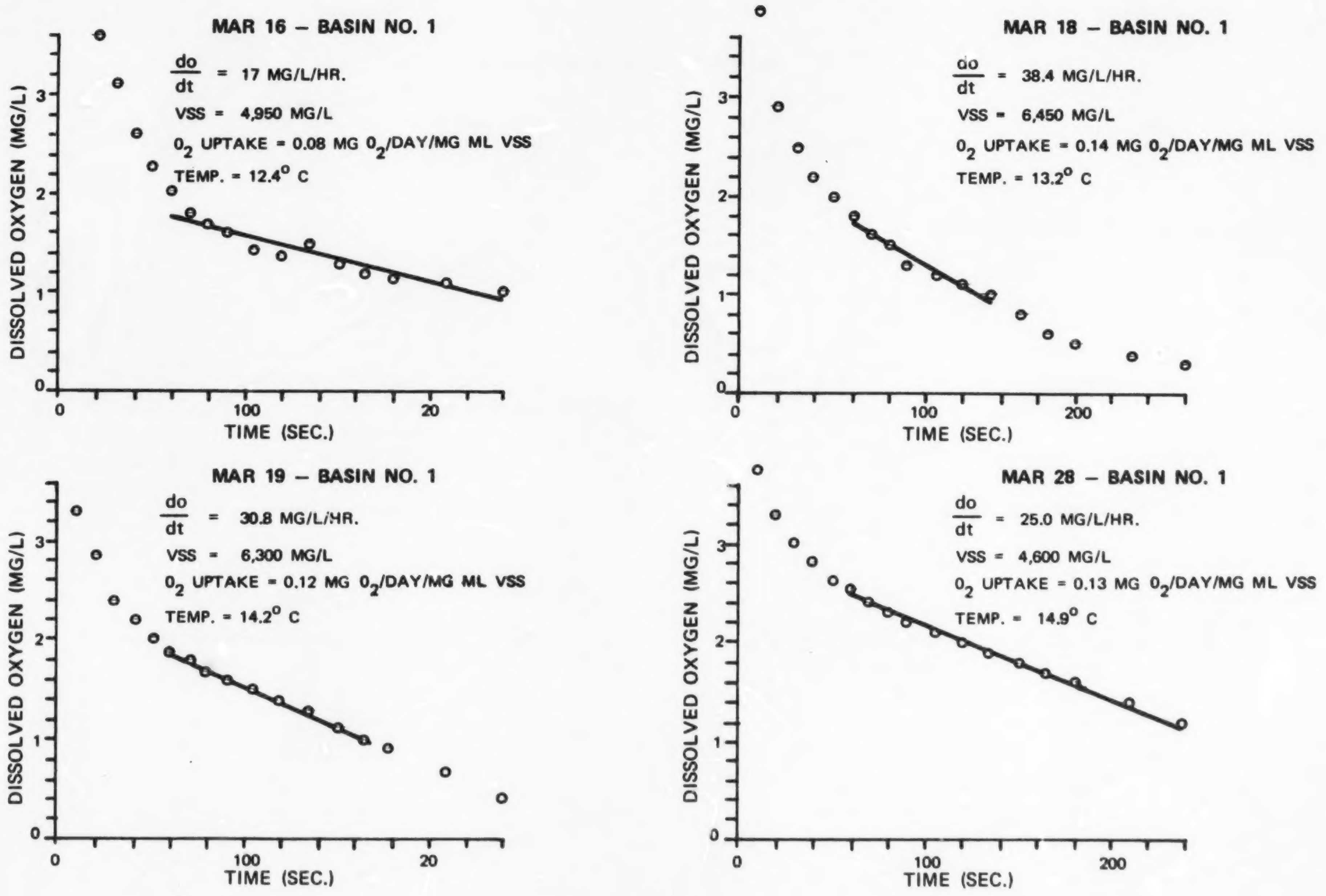
THE R. T. FRENCH COMPANY
SHELLEY, IDAHO

DISSOLVED OXYGEN PROFILE
BASIN 2
9 AERATORS



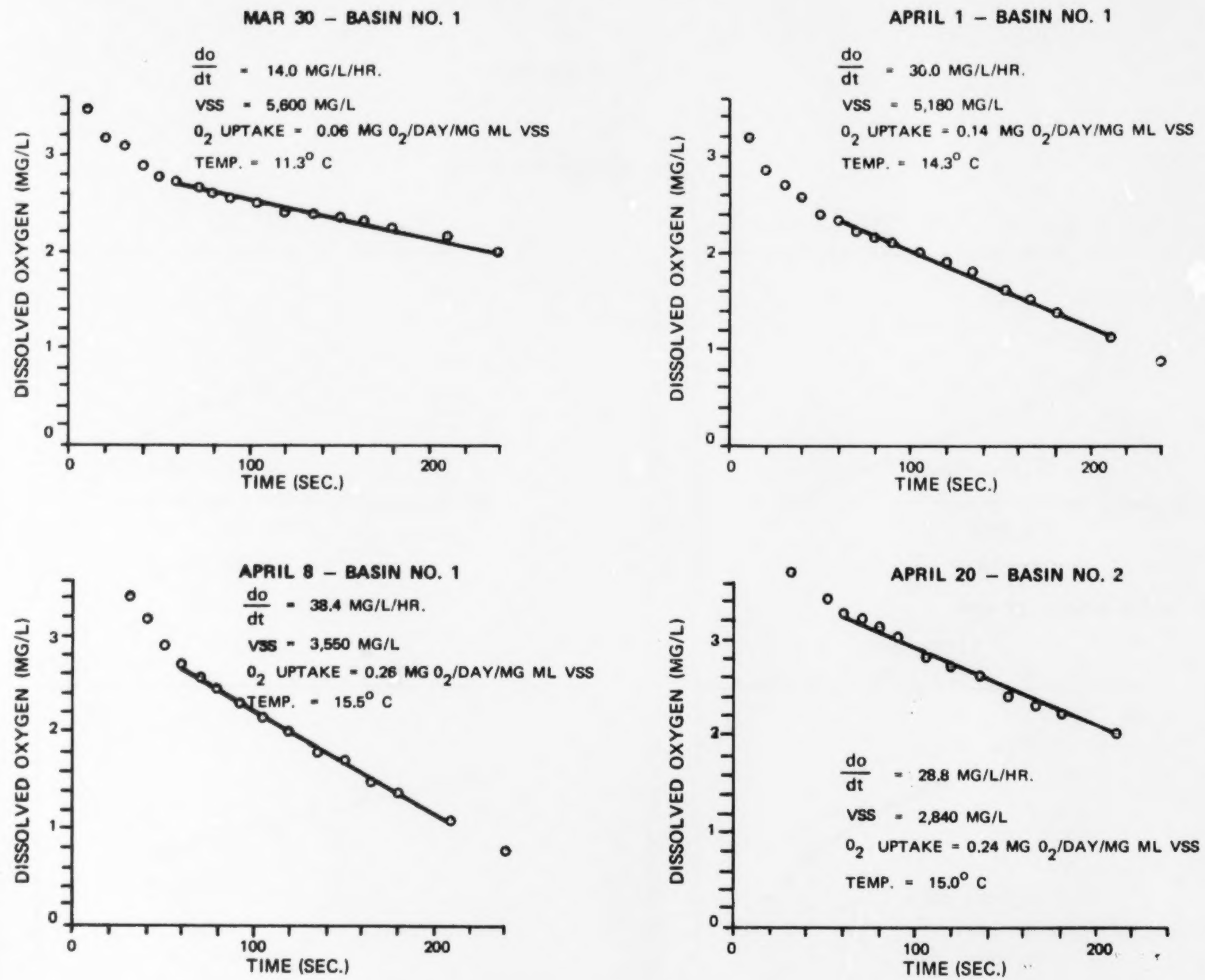
OXYGEN UPTAKE DATA

FIGURE G–6



OXYGEN UPTAKE DATA

FIGURE G–7


MAR 30 – BASIN NO. 1

$\frac{do}{dt}$ = 14.0 MG/L/HR.
VSS = 5,600 MG/L
0_2 UPTAKE = 0.06 MG 0_2/DAY/MG ML VSS
TEMP. = 11.3° C

APRIL 1 – BASIN NO. 1

$\frac{do}{dt}$ = 30.0 MG/L/HR.
VSS = 5,180 MG/L
0_2 UPTAKE = 0.14 MG 0_2/DAY/MG ML VSS
TEMP. = 14.3° C

APRIL 8 – BASIN NO. 1

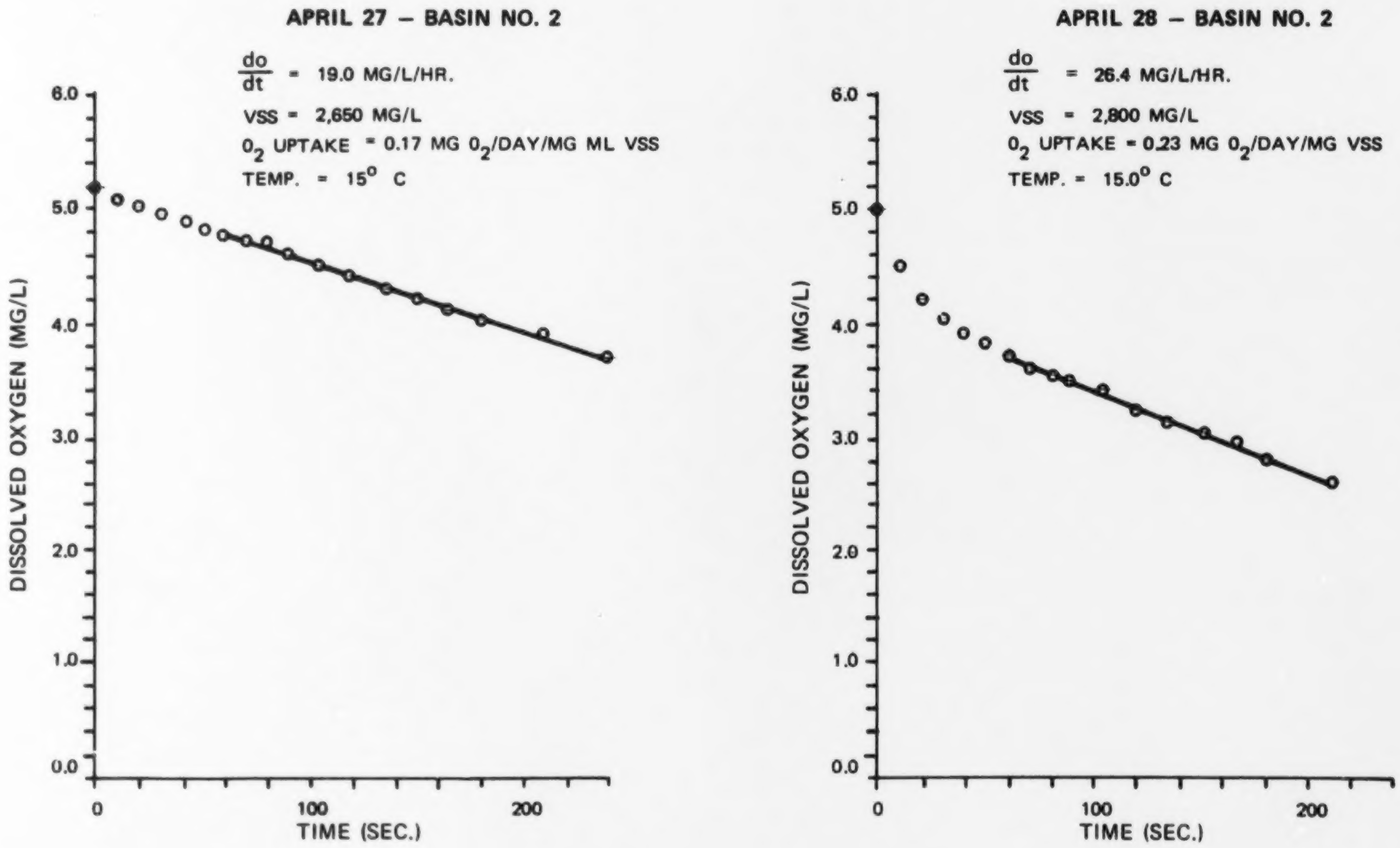
$\frac{do}{dt}$ = 38.4 MG/L/HR.
VSS = 3,550 MG/L
0_2 UPTAKE = 0.26 MG 0_2/DAY/MG ML VSS
TEMP. = 15.5° C

APRIL 20 – BASIN NO. 2

$\frac{do}{dt}$ = 28.8 MG/L/HR.
VSS = 2,840 MG/L
0_2 UPTAKE = 0.24 MG 0_2/DAY/MG ML VSS
TEMP. = 15.0° C

OXYGEN UPTAKE DATA

FIGURE G–8



OXYGEN UPTAKE DATA

FIGURE G–9

APPENDIX H

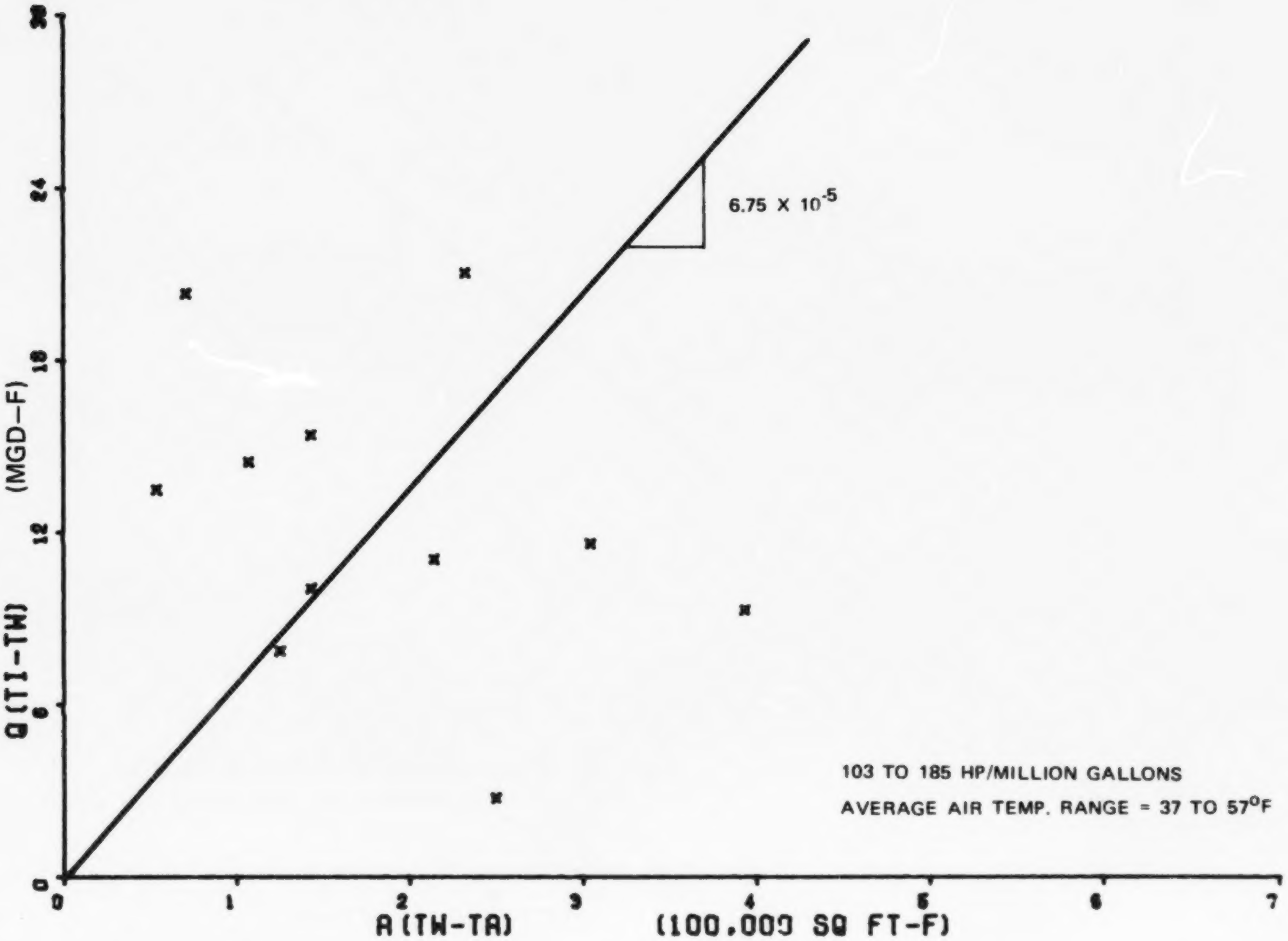
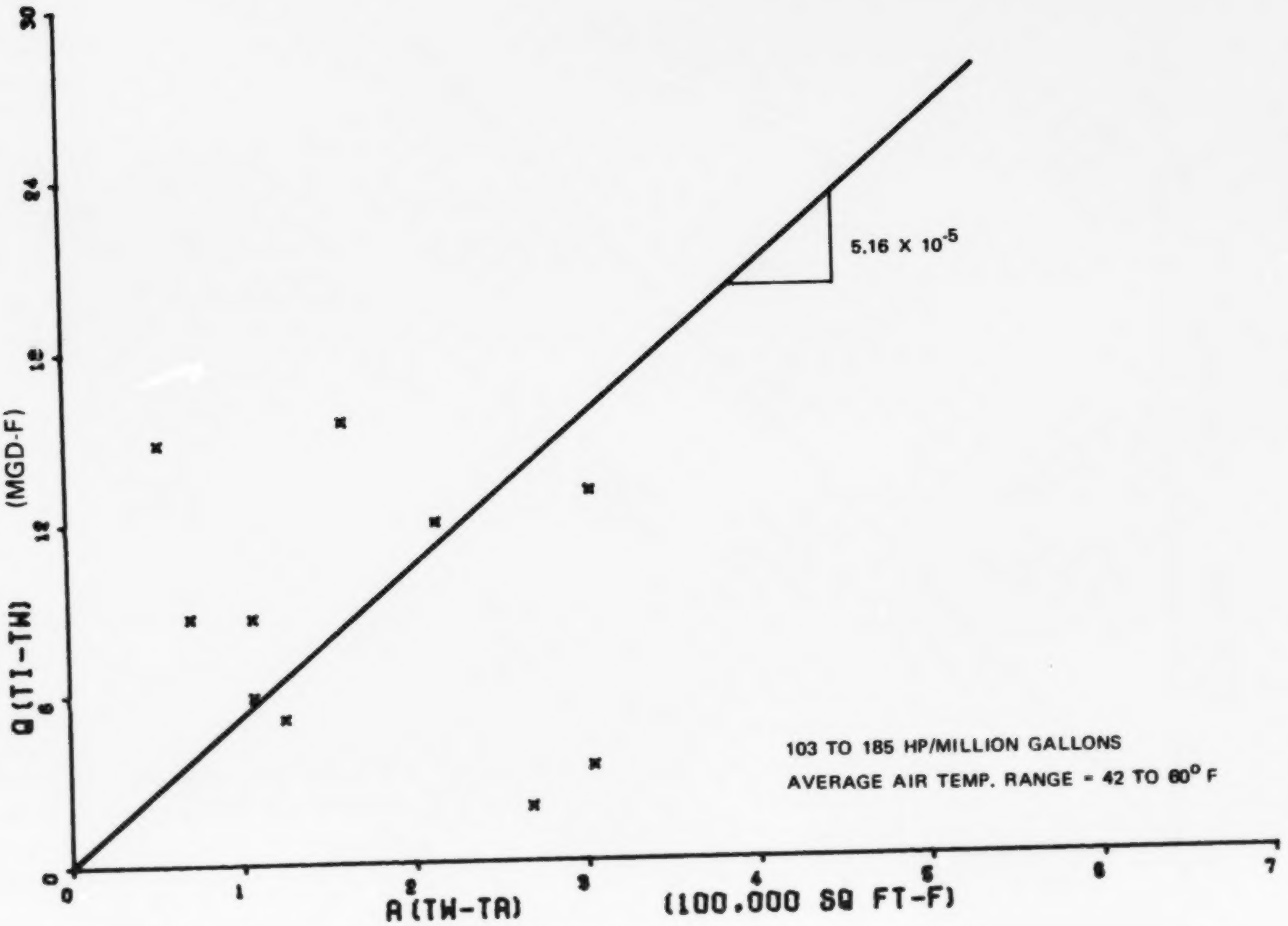


FIGURE H-1

AERATION BASIN HEAT LOSS RELATIONSHIP
1.0 – 2.0 DAYS DETENTION TIME
(ALL DATA)



103 TO 185 HP/MILLION GALLONS

AVERAGE AIR TEMP. RANGE = 42 TO 60° F

FIGURE H–2

AERATION BASIN HEAT LOSS RELATIONSHIP
2.0 – 3.5 DAYS DETENTION TIME
(ALL DATA)

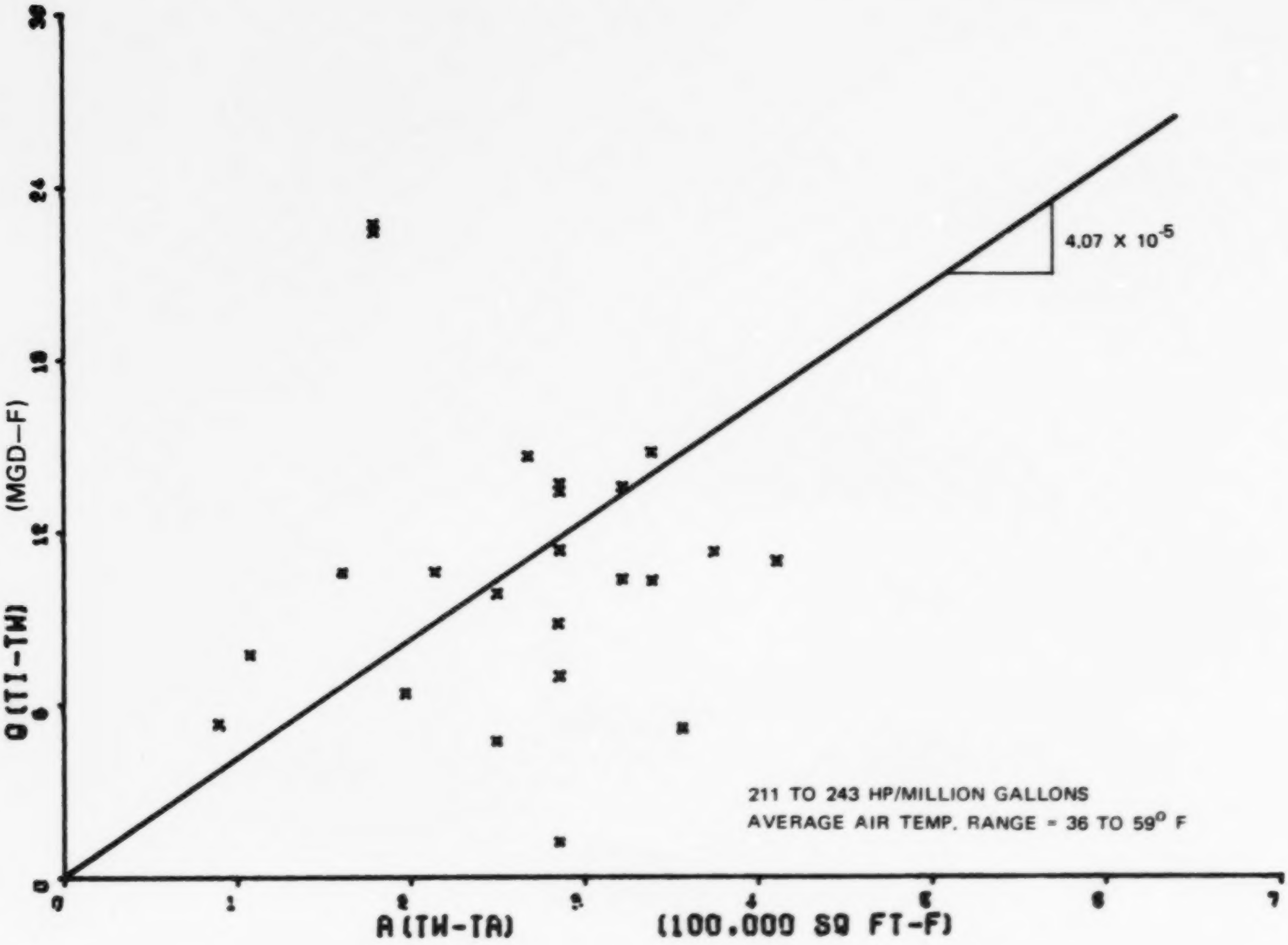


FIGURE H–3

AERATION BASIN HEAT LOSS RELATIONSHIP
0.9 – 1. 5 DAYS DETENTION TIME
(ALL DATA)

1 Accession Number

2 Subject Field & Group
05D

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 Organization
French Co., The R. T., Shelley, Idaho

6 Title
AEROBIC SECONDARY TREATMENT OF POTATO PROCESSING WASTES

10 Author(s)
French Co., The R. T.

16 Project Designation
(WPRD 15-01-68) 12060 EHV

21 Note

22 Citation

23 Descriptors (Starred First)
*Waste treatment, *Secondary treatment, *Industrial wastes, Activated sludge, Aeration, Treatment facilities

25 Identifiers (Starred First)
*Potato processing wastes, Food processing wastes, Waste treatment costs

27 Abstract
A new secondary treatment facility at the R. T. French Company, Shelley, Idaho, has demonstrated the feasibility of a complete mix activated sludge system for secondary treatment of potato processing wastes. The secondary treatment facility was designed for an average daily flow of 1.25 million gallons per day and a BOD loading of 14,100 pounds per day. Frequent aerator shutdowns following mechanical problems have limited oxygen transfer and biological activity in the aeration basins; however, BOD removals of over 90 percent have been obtained for extended periods of time, demonstrating the applicability of the activated sludge process for treating the wastes. These removals have been obtained with: (1) MLSS concentrations between 2,000 mg/l and 8,000 mg/l, (2) aeration basin D. O. concentrations between 0.3 mg/l and 5.2 mg/l, (3) aeration basin temperatures between 45 degrees F and 67 degrees F, (4) aeration basin pH between 7.1 and 8.4, (5) organic loadings between 10 and 120 lb BOD/1,000 cu ft/day, (6) hydraulic detention times of 0.9 to 8.7 days, and (7) BOD/MLVSS ratios of 0.15 to 0.47.

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